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Canadian Strategic Highway Research Program – C-SHRP

Executive Summary

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PROPOSED C-SHRP PROGRAM AND BUDGET OPTIONS
EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1 Canada's Highway Investment

Three levels of government in Canada spend about six billion dollars a year to preserve an investment of some 70 to 80 billion dollars which society has put into its highway infrastructure.

Of this 70 to 80 billion dollars of investment, 12 billion are represented by the nation's 54,250 bridges and over 60 billion dollars by almost one million kilometers of roadway.

Breaking down the six billion dollars of annual maintenance expenditure, nearly 150 million are spent toward the preservation and restoration of our structures, nearly 500 million on winter maintenance, and more than 5 billion a year on roadway preservation and restoration.

1.2 Trends in Annual Expenditure

The last ten years have seen a gradual shift of emphasis from capital to maintenance and operating budgets. In 1975/76 the maintenance and capital shares were 29% and 57% respectively of total highway expenditures. By 1980/81 these shares had changed to 38% on maintenance and 45% on capital expenditures.

There is a need to squeeze as much economy as possible out of the ways in which we do highway engineering in Canada, by optimizing materials, equipment, and design, construction and maintenance procedures. We need to enhance our highway engineering acumen through a quest for practical, innovative solutions to the problems that we have still not solved, and which plague us, because we suspect that they prevent us from achieving the most economical use of our man-power and materials.

1.3 Productivity Gains from the C-SHRP Program

Highway infrastructure maintenance costs can be reduced by improved utilization of the resources which are made available. Improved utilization of resources can come only from improved knowledge of highway materials and their appropriate application under peculiarly Canadian conditions such as climate, material sources and our construction and maintenance practices.

In Canada we have the advantage of not having reached the level of deterioration on our highway system as compared to the United States. This lead time will result in considerable productivity gains before our own roads are due for rehabilitation if we actively participate now.

If we could, through improved utilization of resources, realize a return of but one percent of our annual expenditures we could at no new cost:

- resurface 1000 km of 2 lane roads
- rebuild 300 bridges
- add 1000 km of truck climbing lanes on our 2 lane rural highways

This quest for solutions and subsequent dissemination of products, are what is being proposed in this report at a cost that is envisaged at about one-tenth of one percent of Canada's one year highway expenditure, spread over essentially five years.

2.0 COMPONENTS OF THE C-SHRP

2.1 General

C-SHRP will pursue productivity gains by benefiting from the large SHRP activity in the United States ($150 million over 5 years and $10 million a year for another 15 years), and by solving at a much lower cost, a set of uniquely Canadian problems which have been put forward by our experts across the country.

The program originally put forward to the board consisted of three major thrusts; a monitoring function, an integrated program and a complimentary research program to be carried out here in Canada. In recognition of the vast amount and complexity of information which will be generated by the U.S. SHRP however, a new work element has been drawn out from the original monitoring and complementary research programs to stand on its own. This new element is the technology transfer (T^2) thrust.

Thus, the C-SHRP proposal in this report has four constituent elements as described below:

- Monitoring — collecting and disseminating information on both U.S. and Canadian research activities and identifying Canadian opportunities for the implementation of practical solutions.

- Technology Transfer — there is a compelling need to help individual Canadian jurisdictions to recognize the implications of SHRP and C-SHRP findings for their own design, construction and quality control procedures, and to update the C-SHRP plan itself in the light of new information.

- The Integrated Program — Canadian sites and facilities would be incorporated into the American research program with responsibility for testing falling directly to SHRP. Canadian agencies would retain responsibility for local arrangements such as traffic control, and coordination of site visits by the SHRP contractor.

- The Complementary Research Program — A Canadian research program funded by Canadian agencies would be undertaken to seek solutions to uniquely Canadian problems, complementary to but not duplicating, problems addressed by SHRP.

2.2 Technical Areas in C-SHRP

Six technical areas have been selected for special research effort in the SHRP Program in the United States and in the C-SHRP Program in Canada. These are as follows:

- Asphalt Technical Research Area (T.R.A.)
- Long Term Pavement Performance T.R.A.
- Maintenace Cost Effectiveness T.R.A.
- Protection of Concrete Bridge Components T.R.A.
- Cement and Concrete T.R.A.
- Snow and Ice Control T.R.A.

These have been further "clustered" in C-SHRP, particularly from the perspective of technology transfer, into three delivery areas:

- Area 1: Pavements Related Cluster
  This area groups the three SHRP technical thrusts related to pavements:
  (a) Long Term Pavement Performance
  (b) Asphalt
  (c) Maintenance Cost Effectiveness

- Area 2: Structures Related Cluster
  Two SHRP thrusts are grouped together here:
  (a) Cement and Concrete
  (b) Protection of Concrete Bridge Components

- Area 3: Snow and Ice Control Cluster
  This C-SHRP area corresponds to the technical thrust of the same name to be carried out in the U.S.

This "clustering" of thrusts attempts to recognize the overlap of mutually supportive areas and thus to gain efficiencies in analyzing and summarizing information related to common goals. This is particularly important when dealing with the technology transfer portion of our work.

2.3 Proposed Budget for C-SHRP

A proposed summarized budget for C-SHRP is set out in tabular form in Appendix "A" attached to this report. Salient points from this budget are noted in point form below:

- Total cost of the program ranges from $4,076,500 to $6,006,500, including the budget for the C-SHRP coordinator which is already in place.

- The program extends over 8 years with the effort breaking down as follows:

  1. Year 0: (1986/7) — development and organization of C-SHRP
  2. Year 1 to 5: (1987-1991) — C-SHRP ongoing
  3. Years 6 & 7: — C-SRHP wind down and concluding T^2 efforts

- This budget does not include provision for LTPP work beyond year 5.

- Allocation to each program area over the duration of C-SHRP summarizes as follows:

Monitoring:	$ 367,500
T^2:	$ 510,000
Integrated Program:	$ 590,000
Complementary Research: Options 1 - 5	$4,019,000 to $2,089,000
Coordinator:	$ 520,000

3.0 OPTIONS

3.1 Introduction

This section addresses two issues. First the benefits from each of the four main components of C-SHRP are outlined. Then five levels of funding for the Complementary Program are simulated and the most highly desirable projects to meet each level are selected.

3.2 Benefits

Each of C-SHRP areas has an important contribution to make to the success of any program we undertake. As such, in strict terms it is preferable to discuss desirable overall level of effort and then scale budgets in each of the four areas appropriately than to consider C-SHRP as a divisible entity from which modules can be cut.

- *Monitoring*

  Provides the general collection and dissemination mechanism for information related to both SHRP and C-SHRP. Operating at the "general" level this program should reach the broadest audience of practicing professionals in the country.

- *Technology Transfer*

  Although it is recognized that the U.S. SHRP concentrates on producing practical tools for specialist/practitioners at all levels, experience has shown that research results are not always easily transferable from one jurisdiction to another. The technology transfer program will provide an interpretative mechanism when required to expedite the translation of U.S. work into Canadian terms.

- *Integrated Program*

  Allows us to contribute to the U.S. program as a full partner, thus gaining free access to all data from the LTPP. In addition, site specific characteristics related to Canadian conditions can be studied as part of the U.S. SHRP, thus increasing our confidence in their applicability to our situation. This program provides us with a set of bench marks we can depend on.

- *Complementary Research*

  Canadian conditions, while similar to those found in the U.S. are not identical. Differences exist in climate, subsoil conditions, crude resources for asphalt cements, aggregate types, traffic volumes, heavy vehicle weights and dimensions etc. In many cases the differences are significant. This program lets us answer specific Canadian questions related to, but not directly answered by the U.S. effort. It should let us "lower" our research dollar into producing more effective results.

  The "Core" list of projects for inclusion in C-SHRP are listed with their applicable costs in Appendix "B".

3.3 Complementary Program Options

Priority ratings of the "core" C-SHRP Complementary projects were obtained from provincial representatives and members of the Council on Highway Transportation Research and Development (CHTRD) after the second draft of the C-SHRP Report was circulated for review and comments. After minor modifications by the executive of the Council, the order of the 19 projects in Appendix "B" was developed.

From this list, five options were considered. Option 1 was the result of assuming that all projects would be funded. Options 2, 3, 4 and 5 were developed, in turn, by selecting the best projects from the previous option to meet several levels of C-SHRP expenditures. These levels were set from about $6,006,500 down to $4,076,500 in steps that were as nearly equal as they could be made without terminating projects before completion.

These options are shown in Appendix "C", with notes to indicate the loss to productivity that would be sustained as a result of such budgeting strategies.

4.0 C-SHRP ORGANIZATION AND MANAGEMENT

4.1 Introduction

It is proposed that the Canadian Strategic Highway Research Program operate under an executive committee which reports directly to the Roads and Transportation Association of Canada's Board of Directors. This C-SHRP Executive Committee would be responsible for providing policy guidance for the entire program, providing overview guidance to the technical program and making recommendations to the RTAC Board of Directors.

The execution of C-SHRP would fall under the guidance of the C-SHRP national coordinator. The C-SHRP regional coordinators would form the Technical Steering Committee, which would provide technical direction and oversight.

A mid-program review will be scheduled to look at progress of all aspects of C-SHRP. To facilitate this, each component must carry out their review, evaluation and recommendations. The Executive Committee will make final recommendations to the RTAC Board of Directors.

4.2 Organization Chart

The organization chart is shown in Appendix "D".

5.0 SUMMARY OF BENEFITS

- Infrastructure maintenance and rehabilitation costs approach 6 billion dollars per year in Canada at all levels of government. The proposed C-SHRP is about 1 million dollars per year, or 0.02% of our annual investment in related areas. If only a one percent overall saving in annual infrastructure maintenance costs can be realized through C-SHRP this will yield a benefit of $60 million per year.

- At an annual cost over the 5 core years of C-SHRP of about $1 million, the potential benefit cost ratio is 60:1 for one year's expenditure alone.

  If we can prolong pavement life on Canada's 2-lane paved roads (220,000 km) by just one year (i.e. defer resurfacing costs) then a benefit of about $1,000,000,000 will accrue.

  In the highway structures area, if we can defer maintenance on the highway bridge inventory by one year by applying C-SHRP and SHRP results then a total benefit of almost $14,000,000 will accrue through the system.

  Snow and ice control is a major problem in this country. Indications are that with even a 1% reduction in damage to the environment, a benefit of almost $16 million accrues.

APPENDIX "A"

BUDGET OVERVIEW

C-SHRP

Program Budget Overview

Year	0	1	2	3	4	5	6	7	Total
Coordinator	**70k**	**70k**	**70k**	**70k**	**70k**	**70k**	**70k**	**30k**	**520k**
ITEM									
(A) Monitoring									
Information Management System		75k	45k	40k	40k	30k	—	—	230k
Newsletters		7.5k	7.5k	7.5k	7.5k	7.5k	—	—	37.5k
Seminars		20k	20k	20k	20k	20k	—	—	100k
(B) Technology Transfer									
Cluster 1 (Pavements) Cluster 2 (Structures) Cluster 3 (Snow & Ice)		0	50k	100k	120k	130k	80k	30k	510k
(C) Integral Program									
AVC/WIM Equipment		45k	45k	0	0	0	—	—	90k
Loaned Staff		100k	100k	100k	100k	100k			500k
(D) Complementary Program									
Option 1		714k	845k	855k	890k	815k	—	—	4019k
Option 2		634k	765k	690k	655k	475k	—	—	3219k
Option 3		634k	690k	585k	505k	425k	—	—	2839k
Option 4		484k	530k	585k	400k	450k	—	—	2449k
Option 5		384k	470k	495k	420k	320k	—	—	2089k
Totals									
Option 1	70k	1031.5k	1182.5k	1192.5k	1247.5k	1072.5k	150k	60k	6006.5k
Option 2	"	951.5k	1102.5k	1027.5k	1012.5k	832.5k	"	"	5206.5k
Option 3	"	951.5k	1027.5k	922.5k	862.5k	782.5k	"	"	4826.5k
Option 4	"	801.5k	867.5k	922.5k	757.5k	807.5k	"	"	4436.5k
Option 5	"	701.5k	807.5k	832.5k	777.5k	677.5k	"	"	4076.5k

APPENDIX "B"

CORE RATED LIST OF CANDIDATE COMPLEMENTARY RESEARCH PROJECTS

COMPLEMENTARY RESEARCH PROJECTS

Project No.	Project Title	Project Cost
1) A-1	Further Monitoring of the Vehicle Weights and Dimensions Test Sites	$ 175,000
2) C-3	Corrective Measures for Ruts in Flexible Pavements	50,000
3) B-1	Continual Observation of Pavement Performance	500,000
4) C-4	Improved Materials and Equipment for Pavement Surface Repairs and Crack Filling	300,000
5) A-2	Pavement Performance Evaluation of A,B,C Quality Asphalts	164,000
6) D-1	To Quantify the Service Life of Existing Canadian Methods of Protection and Rehabilitation on Decks, Beams, Piers and Abutments	300,000
7) B-2	Design Method for Bituminous Surface Treatment	600,000
8) F-1	(Buying into) Snowdrifting/Blowing Project	80,000
9) A-3	Field Verification of Laboratory Results on A,B,C Quality Asphalts	150,000
10) C-1	Removal of Hazards due to Ravelling of Granular Shoulder Material at Edge of Pavement	130,000
11) F-2	Expert System to Combine Snowdrifting Control and Geometric Design Constraints	60,000
12) D-3	Synthesis of Research on Load-carrying Capacity of Bridges into Evaluation Guidelines	120,000
13) E-1	Fibre Shotcrete	150,000
14) D-2	Economic Feasibility of Making Corrosion-Resistant Reinforcing Steel	60,000
15) B-3	The Effects of Very Heavy Loads on BST	250,000
16) F-3	Immobilizing Deicing Chemicals	30,000
17) C-2	Demonstration of Technology to Automate the Measurement of Pavement Distress	100,000
18) E-3	Development of Premium Cement	500,000
19) E-2	Alkali-carbonate Reactivity	300,000
	Total	$ 4,019,000

APPENDIX "C"

INVESTMENT OPTIONS

OPTION 1

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2	150	200	100	100	50	600	2089	4076.5
8) F-1	80					80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1		60	50	20		130	2449	4436.5
11) F-2		20	20	20		60	2509	4496.5
12) D-3		30	30	30	30	120	2629	4616.5
13) E-1		50	50	50		150	2779	4766.5
14) D-2		30	30			60	2839	4826.5
15) B-3		75	75	50	50	250	3089	5076.5
16) F-3			30			30	3119	5106.5
17) C-2			100			100	3219	5206.5
18) E-3			75	225	200	500	3719	5706.5
19) E-2			70	70	160	300	4019	6006.5
	714	845	855	890	715	4019		

The total cost for doing all 19 projects of the Complementary Program would amount to $ 4,019,000. The cost of the other components of C-SHRP (Monitoring, Technology Transfer, Integral and Coordinator), amounts of $ 1,987,500. The overall total of C-SHRP would be $ 6,006,500.

These 19 projects of the Complementary Program represent the "core" of all of the projects considered. They have undergone a thorough review and analysis by Canadian transportation experts. Dropping any of these projects will result in losses of productivity and an incomplete strategic program.

OPTION 2

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2	150	200	100	100	50	600	2089	4076.5
8) F-1		80				80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1			60	50	20	130	2449	4436.5
11) F-2			20	20	20	60	2509	4496.5
12) D-3		30	30	30	30	120	2629	4616.5
13) E-1			50	50	50	150	2779	4766.5
14) D-2				30	30	60	2839	4826.5
15) B-3		75	75	50	50	250	3089	5076.5
16) F-3			30			30	3119	5106.5
17) C-2				100		100	3219	5206.5
	634	765	690	655	475	3219		

This option would result in the loss of projects E-3: Development of Premium Cement and E-2: Alkali-carbonate and other reactivity problems. This loss would mean having to forego potential advances to the state-of-the-art in cement and concrete technology, and in turn, to the technology of building longer lasting concrete bridges and pavements. If one bridge was to be saved by such an advance in the state-of-the-art, then these project costs will have been well invested.

Consequences

- Loss of opportunity to extend life of structures.

OPTION 3

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2	150	200	100	100	50	600	2089	4076.5
8) F-1		80				80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1			60	50	20	130	2449	4436.5
11) F-2			20	20	20	60	2509	4496.5
12) D-3		30	30	30	30	120	2629	4616.5
13) E-1			50	50	50	150	2779	4766.5
14) D-2				30	30	60	2839	4826.5
	634	690	585	505	425	2839		

This option would result in the further loss of projects B-3: The Effects of Very Heavy Loads on BST; F-3: Immobilizing De-icing Chemicals; and C-2: Demonstration of Technology to Automate the Measurement of Pavement Distress .

BST is used as a low-cost alternative surfacing strategy when traffic is low. This technology has widespread application to low volume provincial and municipal roads. The loss of an opportunity to explore the impact of heavy trucks will leave uncertainty about what to expect whenever such traffic occurs.

Not exploring exploring the possibility of immobilizing de-icing chemicals will mean a loss of a chance to reduce the amount of de-icing chemicals used and the considerable damage to the environment caused by such use. Reducing the number of applications of deicing chemicals will enhance safety.

The loss of the project to demonstrate automated pavement distress assessment would mean loss of potential to replace inconvenient, time consuming and hazardous normal methods. It will also result in the Canadian loss of its current "technology edge" it has in this area.

Consequences

- Loss of opportunity to reduce maintenance costs and environmental damage,
- Safety,
- Poor pavement management practices and recognition of problem areas,
- Loss of current "technology edge".

OPTION 4

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2		150	200	125	125	600	2089	4076.5
8) F-1					80	80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1			60	50	20	130	2449	4436.5
	484	530	585	400	450	2449		

This option would result in the further loss of projects F-2: Expert System to Combine Snowdrifting Control and Geometric Design Constraints; D-3: Synthesis of Research of Load-carrying Capacity of Bridges into Evaluation Guidelines; E-1: Fibre Shotcrete; and D-2: Economic Feasibility of Making Corrosion-resistant Reinforcing Steel.

The loss of the project to develop an expert system would mean failure to transfer our technology as fully as possible.

The loss of research on load-carrying capacity of bridges would mean continued lack of unified bridge evaluation methods.

The loss of the opportunity to document the advantages of fibre shotcrete to substructures rehabilitation and stabilization of rock cuts would mean that the majority of jurisdictions in Canada would lose some of the potential for producing gain inherent in its use.

The loss of the project to investigate corrosion-resistant steel will mean that the potential for spending less on this large-volume item will be lost.

Consequences

- Overdesign and underutilization of bridges,
- Safety,
- Loss of opportunity to reduce costs of winter maintenance,
- Reduction in longevity of structures.

OPTION 5

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1		100	100	100		300	1489	3476.5
7) B-2		150	200	125	125	600	2089	4076.5
	384	470	495	420	320	2089		

This option would result in the further loss of projects F-1: (Buying into) Snowdrifting/Blowing Project; A-3: Field Verification of Laboratory Results on A,B,C Quality Asphalts; and C-1: Removal of Hazards due to Ravelling of Granular Shoulder Material at Edge of Pavement.

The loss of the project on blowing snow could mean that jurisdictions with this problem would continue to have blocked roads and safety hazards.

The loss of project A-3 would mean the incomplete use of the results of A-2.

The loss of the project on ravelling could mean combined hazard, expense and liability in the courts for injury and property damage.

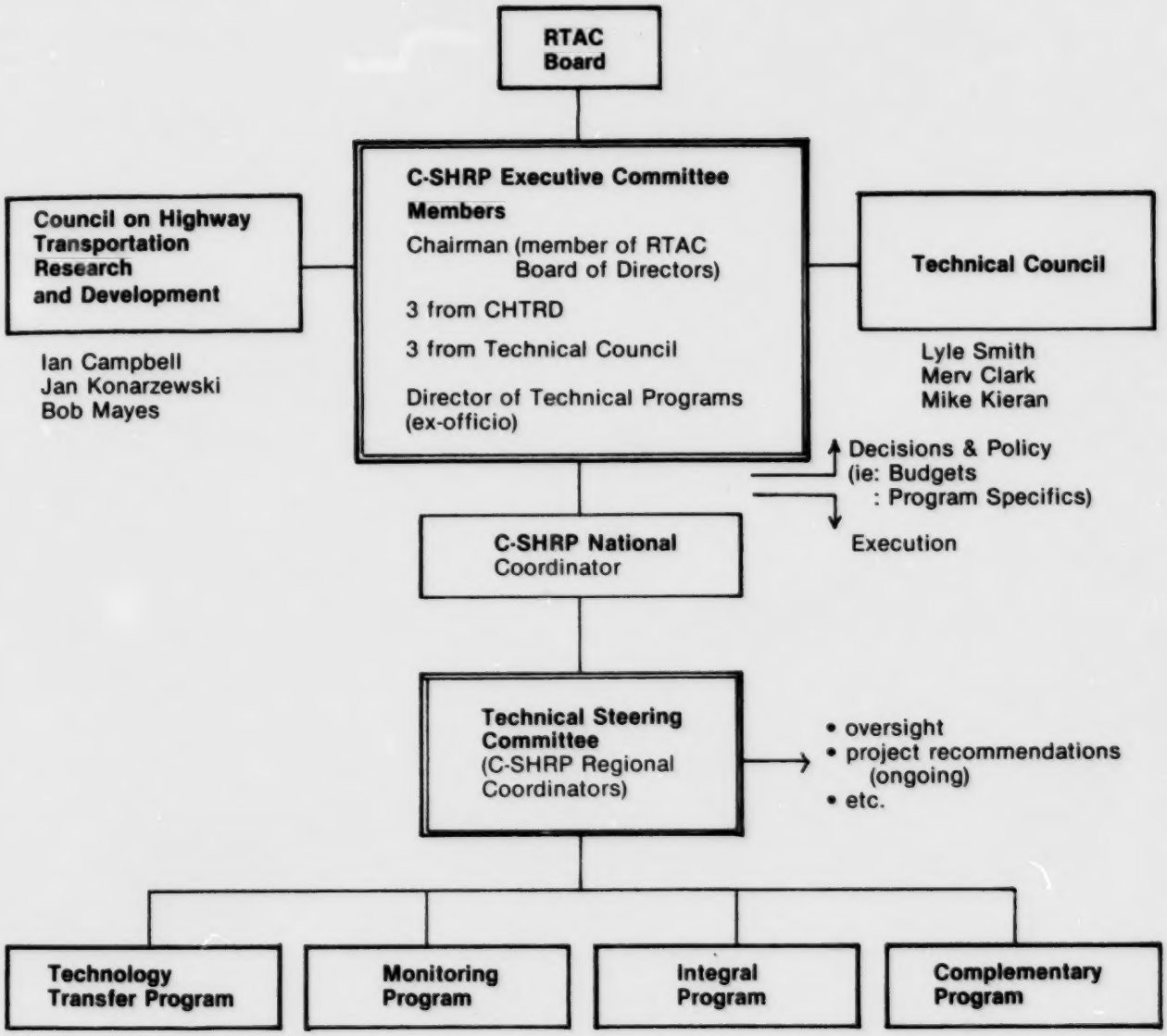
Consequences

- Decreased safety,
- Increased maintenance costs,
- Failure to fully benefit from investment in previous project.

APPENDIX "D"

C-SHRP ORGANIZATION CHART

C-SHRP Organizational Chart



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- ASPHALT
- LONG TERM PAVEMENT PERFORMANCE
- MAINTENANCE COST EFFECTIVENESS
- CONCRETE BRIDGE COMPONENTS
- CEMENT AND CONCRETE
- SNOW AND ICE CONTROL

ABSTRACT

- The Roads and Transportation Association of Canada (RTAC) is recognized by the international transportation community as a focal point for cooperation and coordination. Many individuals across Canada, through the coordination of RTAC, contributed to the determination and direction of the Strategic Highway Research Program (SHRP) in the United States.

- The administrators of SHRP have indicated a need and a willingness for international participation in their program.

- It is to Canada's advantage to cooperate and participate in SHRP thereby expanding the United States program. Canada can share the benefits, and act as a role model of a partner in future international research.

- In Canada we have the advantage of not having reached the level of deterioration on our highway system as compared to the United States. This lead time will result in considerable productivity gains before our own roads are due for rehabilitation if we actively participate now.

- This participation can result in significant near term benefits to the Canadian transportation community for a small commitment of funds compared to the resources which will be committed to the United States program.

- RTAC should play an active role in developing Canadian monitoring, integral, technology transfer and complementary research aspects of SHRP. These activities will for convenience be known as the Canadian Strategic Highway Research Program (C-SHRP). The four components of C-SHRP consist of the following activities:

  - Monitoring - relaying usable results to Canadian agencies by establishing an information management system, publishing newsletters and conducting seminars.

  - Integral - providing Canadian test sites and coordinating information exchange with SHRP. Providing loaned staff.

  - Technology Transfer - providing the interpretive mechanism for implementing research results in three clusters: 1) Pavements (Asphalt, Long Term Pavement Performance, Maintenance Cost Effectiveness); 2) Structures (Cement and Concrete Technology, Protection of Concrete Bridge Components); 3) Snow and Ice Control.

  - Complementary - providing a Canadian-funded research program to seek solutions to problems complementary to, but not duplicating, those to be undertaken by SHRP and addressing uniquely Canadian conditions. A core program is proposed resulting from the many problems identified and corresponding research proposals.

- The total Canadian activities managed by RTAC are estimated to consist of $367,500 for the monitoring; $590,000 for the integral program; $510,000 for technology transfer, options one to five ranging from $4,019,000 to $2,089,000 for the complementary program. The agencies and corporations

supplying test sites,committee members and research activity will also incur costs in addition to those mentioned above.

- A mid-program review will be required to assess progress to date and approve the continuation of the remaining elements of the program.

CHAPTER 1 - INTRODUCTION

1.1 BACKGROUND

Three levels of government in Canada provide road access to job, recreational and commercial opportunities for all Canadians, by spending about six billion dollars a year to perserve our highway infrastructure, worth some 70 to 80 billion dollars. (By comparison: Statistics Canada estimates that total annual revenues from freight transportation alone, using these roads, is about three billion dollars).

The use of these funds is shifting from capital to maintenance and rehabilitation expenditures. There are two reasons for the shift:

> In the first place, funds are deployed in this way because our highway network is seen as having reached maturity, has remained more or less constant in size over the last decade, and therefore requires infusions of maintenance and rehabilitation effort more than it does expansion.
>
> In the second place, because of a rise in other obligations to society which governments have had to honour, funds available for spending on highways have gone steadily down. This fact has given rise to a justifiably conserving strategy: protect the equity we already have and forget about expansion.

Both of these reasons suggest that there is a need to squeeze as much economy as possible out of the ways in which we do highway engineering in Canada, by optimizing materials, equipment, and design, construction and maintenance procedures. We need to enhance our highway engineering acumen through a quest for practical, innovative solutions to the (relatively few) problems that we have still not solved, and which plague us, because we suspect that they prevent us from achieving the most economical use of our man-power and materials.

A lower-cost, supplementary, but equally compelling need, is to provide as a by-product of any problem-solving program, a compendium of data, usable findings and solutions, and implementation information packages. All media should be considered, and those picked which will ensure the most cost-effective dissemination of these products, from well documented research reports to technician-friendly "cookbooks" for routine reference.

This quest for solutions and subsequent dissemination of products are what is being proposed in this report at a cost that is envisaged at about one-tenth of one percent of Canada's one year highway expenditure, spread over essentially five years.

1.2 SHRP TO C-SHRP: THE UNITED STATES CONNECTION

The United States has just developed its Strategic Highway Research Plan (SHRP): detailed planning for each of six technical areas has just been approved. SHRP, with a total budget of 150 million dollars (US), to be spent over five years, is the largest highway research plan ever undertaken in the world. The program has evolved over several years with the participation of representatives from three levels of government, industry and the university community.

Six technical areas have been selected for special research effort by a committee of the (US) National Research Council:

1. Asphalt
2. Long-Term Pavement Performance
3. Maintenance Cost Effectiveness
4. Protection of Concrete Bridge Components
5. Cement and Concrete
6. Snow and Ice Control

Due to the common transportation interests in Canada and the United States, the Strategic Highway Research Program has been closely monitored since its inception. Mr. Boris Hryhorczuk, Deputy Minister of Manitoba Highways and Transportation, has been the RTAC Canadian representative on the SHRP Task Force. Mr. Bev Hamm, Deputy Minister of Nova Scotia Department of Transportation, has been a member of the SHRP Advisory Committee on overview and integration study. There has been a Canadian representative on each of the six advisory committee, and they are as follows: Mr. Tom Christison (Alberta Research Council) on the Advisory Committee of Long Term Pavement Performance; Mr. Lyle Smith (New Brunswick Department of Transportation) on the Advisory Committee of the Maintenance Cost Effectiveness Study; Mr. Dave Marett (Regional Municipality of Ottawa-Carleton) on the Advisory Committee of the Bridge Protection Study; Mr. Peter Smith (Ontario Ministry of Transportation and Communications) on the Advisory Committee of the Cement and Concrete Study; Mr. Joe Gruspier (Ontario Ministry of Transportation and Communications) on the Advisory Committee of the Snow and Ice Study; and Mr. Richard Langlois (Quebec Ministry of Transport) on the Advisory Committee of the Asphalt Study.

The Canadian participation outlined above has been coordinated through the Roads and Transportation Association of Canada (RTAC) in close consultation with officials of both the American Association of State Highway and Transportation Officials (AASHTO), and the Strategic Highway Research Program. In addition, Transport Canada, through the Research and Development Directorate, funded an exploratory study of opportunities for Canadian involvement in the SHRP in the spring of 1985. The Council on Highway and Transportation Research and Development (CHTRD) of RTAC was assigned a key role in acting as a focus for this and future efforts of the SHRP in Canada. To carry out this role, a meeting of Canadian SHRP representatives and CHTRD members was held in conjunction with the RTAC annual conference in October of 1985. The CHTRD also sponsored a workshop in Winnipeg on November 28 and 29, 1985 involving CHTRD members, Canadian representatives to the SHRP and other selected experts in each of the technical areas defined for the American research program. The results of this workshop were used to help frame out recommendations to the RTAC Board of Directors for continuing collaboration with and monitoring of the Strategic Highway Research Program. They also provided the core of the research program to be carried out under the Complementary Program. A complete list of those in attendance at this meeting is included as Appendix "A".

As a result of the Board's recommendations to become involved in the Strategic Highway Research Program, a committee of regional coordinators has been established. Current membership on this committee is listed in Appendix "A".

The Council on Highway and Transportation Research and Development has played a primary role in developing this proposal for the Roads and Transportation Association of Canada, and a list of their members is also included in Appendix "A".

The Council on Highway Transportation Research and Development provided funding for the development of the C-SHRP proposal. This resulted in Mr. Ataur Bacchus (Ontario Ministry of Transportation and Communications) being enlisted to prepare the material on the Complementary Research Program. The National Coordinator, Mr. John Hill, was also hired on April 1 and developed the remaining part of this proposal. Members of the Executive of the CHTRD, Albert Stevens (University of New Brunswick), I.C. Campbell (Ontario Ministry of Transportation and Communications), J.Z. Konarzewski (Alberta Transportation), R.R. Mayes (Transport Canada), and John Robinson (RTAC), provided continued guidance in the development of the program.

The United States SHRP organization has been very helpful and encouraged Canadian participation in their program. In particular, the SHRP staff, Gary Byrd and Richard McComb, have provided the necessary information and support during the development of the C-SHRP.

1.3 COMPONENTS OF C-SHRP

The workshop held in Winnipeg identified three levels of Canadian involvement with SHRP. A fourth Technology Transfer was subsequently added at a CHTRD meeting in Kelowna, British Columbia.

- Monitoring SHRP

  Monitoring the research as it gets underway and relaying usable results in the optimal format for users in Canada.

- The Integrated Program

  Canadian sites and facilities would be incorporated into the American research program with responsibility for testing falling directly to SHRP. Canadian agencies would retain responsibility for local arrangements such as traffic control, and coordination of site visits by the SHRP contractor.

- Technology Transfer

  There is a compelling need to help individual Canadian jurisdictions to recognize the implications of SHRP and C-SHRP findings for their own design, construction and quality control procedures. Technology transfer provides the interpretive mechanism for translating research results in the U.S. into Canadian terms where necessary.

- The Complementary Program

  A Canadian research program funded by Canadian agencies would be undertaken to seek solutions to problems complementary to, but not duplicating, problems addressed by SHRP. Delegates felt strongly that a pro-active role such as a complementary research program would carry over to the Monitoring and Integrated programs as well.

The reasons for a United States Strategic Highway Research Program are also applicable to a Canadian Strategic Highway Research Program. C-SHRP would not

exist if the U.S. program were not in place. The funding available for C-SHRP is considerably less than that currently available for SHRP. Canada will gain full benefits from SHRP only if it participates fully.

Studies indicate that the need for funds to be spent on infrastructure exceed the financial resources that are available to satisfy these needs. It is felt that by research and innovation, this gap can be narrowed. The United States recognized the need to conduct this research by central coordination. In Canada we should approach the research effort in a similar manner. This is why the Roads and Transportation Association of Canada should act as the co-ordinator of the Canadian approach to this research.

1.4 OBJECTIVES OF INTERNATIONAL PARTICIPATION

International participation in the U.S. Strategic Highway Research Program has been demonstrated by having Canadian representatives on the appropriate task force and committees and by encouraging the international community to attend the U.S. workshop in Dallas. This workshop was held before the program was in full operation so that comments and recommendations could be incorporated into the final proposed program. Another international workshop was also scheduled for May 1986 to let the international community know that their participation was welcomed and encouraged. This international workshop was also scheduled so that any suggestions made at this time could still be incorporated into the final SHRP program prior to full implementation and funding in October 1986. Some of the objectives of international participation that have been identified are:

- Cooperation and Participation
  The first objective is to have cooperation and participation of the international community in SHRP so that the research would be building on current technology and there would be a better knowledge of the current state-of-the-art in the world.

- Expanded Program
  The second objective is to expand SHRP to cover different environmental conditions and designs in other areas of the world.

- Performance and Analysis
  The third objective is to have the international community provide input into the performance and analysis of the research areas of SHRP thereby ensuring the best research that is available in the world would be included in this program.

- Share Benefits
  The fourth objective is to share the benefits with the international participants.

- Role Model
  The fifth objective is to establish a role model for future international research.

In order to fulfil the objectives of international participation the following are suggested:

- Monitoring - relaying usable results to Canadian agencies by establishing an information management system, publishing newsletters and conducting seminars.

- Integral - providing Canadian test sites and coordinating information exchange with SHRP. Providing loaned staff.

- Technology Transfer - providing the interpretive mechanism for implementing research results in three clusters: 1) Pavements (Asphalt, Long Term Pavement Performance, Maintenance Cost Effectiveness); 2) Structures (Cement and Concrete Technology, Protection of Concrete Bridge Components); 3) Snow and Ice Control.

- Complementary - providing a Canadian-funded research program to seek solutions to problems complementary to, but not duplicating, those to be undertaken by SHRP and addressing uniquely Canadian conditions. A core program is proposed resulting from the many problems identified and corresponding research proposals.

The Strategic Highway Research Program will be taking a leadership role in the coordination of this international cooperation and have identified the following as their commitments to the program:

- Establish a data management and information management program
- Provide information access
- Provide standard data requirements (with international consultation)
- Review calibration and correlation of data
- Conferences
- Publications

Some of the issues that have been identified for discussion internationally are as follows:

- Standardization
- Data transmission
- Comparability
- Proprietary findings

With international cooperation and involvement there will certainly be success and rewards. Senior SHRP administrators feel that with some coordination and commitment to the SHRP program, additional research and research findings will be forthcoming from the international community.

CHAPTER 2 -- C-SHRP

In Chapter 2 the four components of C-SHRP will be described in the following order:

- Monitoring Program
- The Integral Program
- Technology Transfer
- Complementary Program

2.1 MONITORING

2.1.1 Introduction

Monitoring - as the American program gets underway there will be a need to monitor what is happening in the program and to disseminate that information to the appropriate agencies and individuals in Canada. Given the extensive nature of the program, with its multiple projects and technically diverse scope, an appropriate mechanism will be required to ensure that this highly complex task is accomplished efficiently.

2.1.2 Monitoring Activities

Information Management System

The SHRP project has looked at hiring a data management consultant to evaluate alternative approaches, to priorize needs, and to select a plan of action for their data management role in the overall SHRP. Their consultant has come up with a concept and design for an information management system. A central system configuration has been developed in which the data flows from the state to the region and then to the SHRP central computers.

Information management is going to be a very important aspect of the monitoring role. The Canadian role in the management information system being developed by SHRP is still somewhat unclear. In order to make the best use of resources available, a Canadian consultant should be hired to coordinate with the SHRP consultant. There will be a need to obtain software and hardware in Canada in order for us to maintain proper information management and exchange of data. Most of the data being generated will be in the area of the long term pavement performance program (LTPP). The LTPP program runs for twenty years whereas the other research areas are for five years. Because this is an area where we have offered to become involved in the integral SHRP project, we should further explore the data management requirements to ensure complete participation. In the United States the hardware and software they will acquire for the data management will probably revert to another organization at the conclusion of the SHRP project. In Canada we should also look at where the future hardware and software may be used in Canada. In order to budget for the data management and information management, it is forecast that a cost of hiring a consultant would probably be about $30,000 and the cost of the hardware and software about $200,000.

Newsletters, Reports

A Canadian newsletter should be prepared outlining the efforts that have been done in C-SHRP and SHRP. The SHRP newsletter may be an insert but the cover portion of the Canadian newsletter would deal with the C-SHRP work. The purpose of the newsletter would be to get out timely information on the SHRP and C-SHRP projects. Since both publication timetable and the audience receiving this material may be different than the current RTAC membership, a separate newsletter than the RTAC News is recommended.

Seminars

To inform interested Canadians on the progress of SHRP and C-SHRP appropriate seminars should be scheduled. It is anticipated that the seminars would be held on a cost recovery basis. In order to keep the costs to a minimum for the participants it may be desirable to have a certain amount of funds available for these seminars, especially since past experience has shown that not all of our workshops can be held on a cost recovery basis. In order to ensure that a loss is not incurred and yet the seminars are given in all locations possible, a budget of $20,000 per year should be allocated.

2.1.3 Cost Estimates

Activity	5-Year Total
Information Management System	$230,000
Newsletters, Report	37,500
Seminars	100,000
Total	$367,500

2.2 INTEGRAL PROGRAM

2.2.1 Introduction

Canadian agencies can if they wish become directly involved in the integral elements of the U.S. SHRP. A general offer has been made that Canadian transportation agencies, through RTAC, are prepared to provide specific test sites and/or experiments to be included as integral elements of SHRP. Areas that have been identified are long term pavement performance (LTPP), asphalt properties, snow and ice, bridge protection, maintenance cost effectiveness, cement and concrete. The exact nature of such an offer depends on the requirements of SHRP and the availability of Canadian resources to participate in this program. To date only the long term pavement performance project has developed to a stage where they are looking for direct Canadian participation in determining potential test sites for this program. These test sites would be for the general pavement studies. With respect to the specific pavement studies only a questionnaire has been developed to date.

In the following two sections two components of the integral program are described: Test Sites and Loaned Staff.

2.2.2 Test Sites

The output of the long term pavement performance project is improved pavement management in the predictions, strategies and designs. The objective of the project is to increase pavement life by investigation of various designs of pavement structures and rehabilitated pavement structures, using different materials and under different loads, environments, sub-grade soil and maintenance practices. The plan for the long term pavement performance includes the following:

- design of a national experiment
- plan for information management
- preliminary planning for organization management
- establishment of the data elements to be collected
- development of a general plan for data collection and selection of state-of-the-art field measurement equipment to optimize data quality and cost
- establishment of working relationships between SHRP and the state highway agencies
- selection of an optimum set of test sections nationwide to meet the requirements of the overall experiment design
- develop an overall implementation plan

The long term pavement performance structure is set-up so that it could support conducting field experiments for the other research areas of SHRP. Direct Canadian participation will be in the general pavement studies and in the specific pavement studies. To date the provincial and territorial coordinators are developing potential test sites for general pavement studies in their province. For the general pavement studies the Unites States SHRP is looking for 960 original sections and 600 rehabilitated sections for a total of 1,560 test sections. For the specific pavement studies they are looking for 632 test sections at 232 locations. The major end products and results of the long term pavement performance studies include 1) more reliable new pavement design procedures and standards, 2) more reliable rehabilitation design procedures and standards, 3) improved cost allocation analysis, 4) more accurate pavement needs estimates, 5) improved pavement management systems, 6) improved pavement maintenance policy. The provinces and territories participating in the integral program are expected to incur the same costs as a state highway agency. The estimated work effort includes the elements discussed below:

- Identification of Candidate GPS Sites

  Identification of general pavement sites is expected to require collection of a sub-set of the inventory data items. It is estimated that development of the required data for an average candidate LTPP site should require approximately 20 man hours, which will include collection of the minimum data set and one visual site review. It is expected that the site review will be accomplished by local or district personnel to minimize travel time and will include taking a few

photographs of the site for review during the site selection process. Once these sites have been tentatively selected a site visit will occur over a period of approximately one week. This will require approximately 4 person hours of provincial work effort per site.

- Inventory Data Collection for GPS Test Sections

Following final selection of the long term pavement performance general pavement studies sites, it will be necessary for the province to collect the remaining inventory data items for the sites selected. It is estimated that this should require approximately 15 person hours per site.

- Assignment of a C-SHRP Coordinator

The early stages of the long term pavement performance effort may require a large percentage of the C-SHRP coordinator's time. It is anticipated that on the average approximately 25% of the coordinator's time should be devoted to the long term pavement performance effort.

- Maintenance Data

The nature of the maintenance data to be collected has not yet been established. It is expected that physical descriptions of the maintenance activities to be performed as well as financial data will be required for the specific test sections. It is estimated that 10 person hours per site will be required.

- Rehabilitation/Reconstruction Data

This data is reported only initially if the test section has been previously rehabilitated or subsequently when rehabilitated/reconstructed during the monitoring period. It is expected that this will require 10 person hours or less where such an event occurs.

- Traffic Count, AVC WIM

It is expected that the primary work effort required from the province with regard to the traffic count, AVC and WIM equipment will be during the installation of the systems. It is estimated that each site will require about 100 person hours for equipment installation, maintenance and repair. It is expected that these sites will become part of the provincial traffic study activity.

- Skid Resistance Data

It is estimated that each site will require approximately 6 person hours for management of the skid resistance data.

- Traffic Control

It is expected that traffic control will be provided during the installation of the AVC and WIM equipment and during the non-destructive pavement testing. A total of approximately 16 person hours will be required for traffic control at each site when the AVC

equipment is installed and, at a later date, another 16 person hours when the WIM is installed.The non-destructive testing of pavements is expected every two years (3 tests) with approximately 8 person hours of traffic control required each time.

- Construction of Special Sections

It is not possible to estimate with much accuracy the provincial work effort required for the construction of special sections. Coordination of specific study requirements with SHRP representatives and identifying the specific design and construction details to be included will be required. Design and bid documents will be developed for each of the test sections. Additional coordination with the contractors will be required because of the stringent construction inspection requirements. The amount of time involved will depend on the scope of the specific experiments and their needs. It is expected that special sections would be constructed as part of a new or reconstructed section of road.

Provinces and territories are encouraged to provide portable weigh-in-motion (WIM) scales for the general pavement study sites. The technology for each site to have weigh-in-motion scales at reasonable cost and perform satisfactorily is foreseen. In the U.S. the SHRP are paying 25% of the state cost for the AVC and WIM. It is proposed that the same policy be applied in Canada with C-SHRP paying 25% of provinces costs for such equipment.

Based on approximately 50 sites at $7200 for equipment purchase of AVC and WIM in Canada, an estimated $90,000 should be collected in order to pay the 25% or $1800 per test site for the equipment. Further negotiations will be held with SHRP to see if funds are available in Canada for these sites. RTAC should provide the funds to the provinces for the sites to encourage state-of-the-art development of equipment.

The costs and procedure for allowing the SHRP regional contractor's test vehicles into the different provinces and territories on a temporary basis to collect the data has to be explored and finalized.

2.2.3 Loaned Staff

As stated in the previous brief, Canadian transportation agencies, through RTAC, are prepared to offer human resources to be directly involved in SHRP management project activities. The following are some of the tentative items to be considered in making loaned staff appointments:

- Loaned staff positions will be filled by the Director, SHRP from candidate applications submitted by international agencies.

- The appointments will be made for a minimum term of six months of full time duties as a SHRP staff member and a maximum of two years. Reappointments may be made subject to staffing needs, performance records and availability of loaned staff members.

- During the term of appointment the loaned staff member will report to his designated SHRP staff supervisor for instructions and directions as to duties to be performed.

- Loaned staff members will be provided with office space, furnishings, facilities (telephone, computer access, typing, copying, etc.) and support services as are customary and required for the duties and responsibilities assigned.

- Loaned staff will remain as employees of the lending agency and will receive wages and employment compensation from their regular employer.

- To compensate loaned staff members for temporary living costs incurred while assigned to SHRP at its Washington, D.C. headquarters or field offices, each loaned staff member may receive from SHRP a per diem lump sum payment of $50.00 per workday based upon a five-day 40-hour work week.

- In addition to the living and housing cost allowance, loaned staff members may be reimbursed by SHRP for all direct costs for travel, hotels, meals and other out of pocket expenses incurred while travelling from their assigned duty location on SHRP business.

Canada has the option of having two different types of loaned staff available for the SHRP program. A senior position is possible in Washington and a junior pavement engineer position with a regional contractor looking after the long term pavement performance projects. Depending on the time commitment RTAC places on the loaned staff, the duties of these people will have to be determined in conjunction with the SHRP Director. The person to look after the Washington location should be selected in 1986 and the regional one in 1987.

RTAC should collect the funds for the loaned staff to ensure all agencies have equal opportunity to participate in the program. A funding arrangement between RTAC and the loaned staff employer could be made.

2.2.4 Cost Estimates

Test Sites

• Identification of candidate GPS		
24 person hours @ $25.00/hr. =	$ 600.00	
• Inventory data collection for GSP Test Sections		
15 person hours @ $25.00/hr. =	375.00	
• Maintenance data		
10 person hours @ $25.00/hr. =	250.00	
• Rehabilitation/reconstruction		
10 person hours @ 25.00/hr. =	250.00	
• Traffic Count, AVC/WIM		
100 person hours @ $25.00/hr. =	2,500.00	
Equipment purchase AVC & WIM = $5400.00 + $1800.00 = $7200	7,200.00	
• Skid resistance data		
6 person hours @ $25.00/hr. =	150.00	
• Traffic Control		
32 person hours @ 25.00/hr. =	800.00	installation
24 person hours @ 25.00/HR. *3 TESTS	1,800.00	at time tests are done.
Total 5-year cost per site =	$13,925.00	

Loaned Staff

	Yearly	5 Year Total
1 position	$ 60,000	$ 300,000
2 positions	$ 100,000	$ 500,000

2.3 TECHNOLOGY TRANSFER

2.3.1 Introduction

Technology transfer in the broadest sense means trying to get products, processes, knowledge or whatever results from research, development and demonstration programs applied and used in the public and private sectors.

To have successful technology transfer a number of factors have to be considered. There has to be a commitment on behalf of senior management to implement the results and dedicate people to the task of technology transfer.

The factors which the end user considers important must be known to effectively transfer technology.

End users of the research need to participate actively in the process of technology transfer. Other considerations are the information-distribution network and acceptance of results.

Although it is recognized that the U.S. SHRP concentrates on producing practical tools for specialist/practitioners at all levels, experience has shown that research results are not always easily transferable from one jurisdiction to another. The technology transfer program will provide an interpretative mechanism when required to expedite the translation of U.S. work into Canadian terms.

Engineers in provincial highway agencies and municipalities will not necessarily be able to free resources for interpretation and synthesis of SHRP and C-SHRP work on all the tasks in these Technical Research Areas. A central, cooperative project in which one researcher does this for all of Canada is cheaper and ensures continuity and non-duplication. It provides for a central organization and ensures effective technology transfer.

Mechanism for implementing this technology transfer should be examined.

Because of the interactions among the six technical research areas in SHRP and C-SHRP, they have been "clustered" into three groups for the purpose of technology transfer. These clusters are:

- Pavements related cluster: (a) Asphalt, (b) Long Term Pavement Performance, and (c) Maintenance Cost Effectiveness
- Structures related cluster: (a) Protection of Concrete Bridge Components, and (b) Cement and Concrete Technology
- Snow and Ice Control cluster

The technology transfer project statements (Appendix "B"), one for each cluster, have been developed.

2.3.2 Pavements Related Cluster

As milestones are reached in the SHRP and C-SHRP research on asphalt, long term pavement performance and maintenance cost effectiveness, there will be need for technology transfer to help individual Canadian jurisdictions to recognize the implications for their own design, construction and pavement management procedures. An expert should be retained to interpret interim findings, screen them for potential benefit to Canadian pavement management, and then relay them in the format(s) conducive to the realization of full benefit.

2.3.3 Structures Related Cluster

As milestones are reached in the SHRP and C-SHRP research on concrete bridge protection and cement and concrete technology, there will be need for technology transfer to help individual Canadian jurisdictions to recognize the implications for their own bridge evaluation and protection procedures. An expert should be retained to interpret interim findings, screen them for potential benefit to Canadian jurisdictions, and then relay them in the format(s) conducive to the realization of full benefit.

2.3.4 Snow and Ice Control Cluster

As milestones are reached in the SHRP and C-SHRP research on snow and ice control, there will be need for technology transfer to help individual Canadian jurisdictions to recognize the implications for their own snow and ice control procedures. An expert should be retained to interpret interim findings, screen them for potential benefit to Canadian jurisdictions, and then relay them in the format(s) conducive to the realization of full benefit.

2.3.5 Cost Estimates

Activity	5-Year Cost
• Pavements Related Cluster	$ 204,000
• Structures Related Cluster	$ 204,000
• Snow and Ice Control Cluster	$ 102,000
Total	$ 510,000

2.4 COMPLEMENTARY PROGRAM

2.4.1 Introduction

Complementary Research Program is a Canadian funded research effort to be undertaken over a five-year period to cover research problems complementary to but not being carried out under the SHRP. Projects undertaken in such a program might tackle areas where unique Canadian perspectives or problems exist, or areas judged to be important to SHRP but which are not being undertaken by the American program for budgetary or other reasons.

This program covers the same six technical research areas as in SHRP

- Asphalt
- Long Term Pavement Performance
- Maintenance Cost Effectiveness

- Protection of Concrete Bridge Components
- Cement and Concrete
- Snow and Ice Control

In section 2.4.4 SHRP and C-SHRP objectives of each of these six technical research areas are given. Detailed project proposals for the complementary program are given in Appendix "C"

2.4.2 Background

The projects in the complementary program originated essentially in discussions at the Winnipeg workshop in November of 1985. A large number of projects was suggested at that workshop and in later discussions with participants. In addition, when the second draft of the C-SHRP report was issued, it was thought that to address issues that might have arisen since the Winnipeg workshop, the opportunity should be extended to the reviewers of that draft to add to the complementary program. The nineteen projects now in the program represent a "core" selection from the much larger number suggested on the different occasions outlined above.

2.4.3 Criteria for Inclusion

Projects considered for inclusion in the C-SHRP Complementary Program were assessed using the following criteria. This process helped narrow down the list to a core selection of nineteen highly desirable projects.

Problem-orientation

The project has to be problem-oriented, not part of an attempt to cover all major highway engineering issues.

To identify the role of a particular project, the following generic objectives were considered:

- a state-of-the-art enhancement, e.g. better understanding at the steel/concrete microstructure interface of what happens during corrosion of bridge reinforcement;
- a demonstration of known techniques to achieve uniformity of knowledge across the country;
- an evaluation technique, e.g. to define level and rate of corrosion in a bridge;
- a prediction model, e.g. to predict service life of a structure in terms of its age, exposure to deleterious contaminants, and original quality;
- rehabilitation strategy (sequence of treatments) and the return on investment in terms of increased life;
- decision model, e.g. to set priorities on rehabilitation of the components of a single bridge, or among several bridges in a highway network.

Pay-off

The first question here is how usable are the results likely to be. "Usable" means translatable into an enhancement of actual practice, i.e. something that is likely to be a cost-effective innovation in the highway technician's job routine.

The second question relates to the first, i.e. whether the innovation is likely to be cost-effective overall. Would savings to be realized by the highway agency be greater than the research and implementation costs?

Prospects

In order to develop a balanced program, the projects were categorized into four subsets: all combinations of high and low probability of success and high and low payoff.

(Payoff)	Low (Probability of Success)	High
High	Low Probability High Payoff	High Probability High Payoff
Low	Low Probability Low Payoff	High Probability Low Payoff

Linkages

The more relationships a project has within its several contexts, the more viable it is likely to be.

Is the project truly complementary to SHRP - are we, by virtue of being involved in the research, in a position to participate in more mutually beneficial exchanges of information with our U.S. neighbours?

Is there a commonality of need with other jurisdictions for the results of this project?

Is this particular project a pre-requisite to other projects? Do we have a case of likely synergy, i.e. where a little extra effort will bring in a greater harvest from other projects?

Duplication

We are after uniquely Canadian problems, and uniquely Canadian approaches to problems.

We should not attempt to achieve what the U.S., with its relative size, is more qualified to do.

We do not include any projects that clearly duplicate U.S. work.

Some areas of research are so complex that, even starting with the same objectives, different researchers will take different approaches to the

problem. In fact, some redundancy is desirable in order to produce confirming results which are essential to decisions on implementation - especially under peculiarly Canadian conditions such as climate, materials, and construction and maintenance practices. Therefore some redundancy may be justified in the more complex projects.

2.4.4 Technical Research Areas

In this section SHRP and C-SHRP objectives are given for each of six technical research areas:

- Asphalt
- Long Term Pavement Performance
- Maintenance Cost Effectiveness
- Protection of Concrete Bridge Components
- Cement and Concrete
- Snow and Ice Control

ASPHALT TECHNICAL RESEARCH AREA

Introduction

Pavements are the most expensive component of highway infrastructure. Asphalt cement is, in turn, the most expensive component of asphalt pavements, and its properties have the single greatest effect on the long-term properties of the pavement. Yet most of the research on asphalt cement has been on the physical and chemical properties, and not on the relationship of these properties to pavement performance.

There are problems related to the study of the relationship between asphalt cement properties and pavement performance. One popular statement in the industry is that "no two asphalts are alike". Canada is about to go to a standard "A" versus "B" versus "C" classification determined through standard tests on physical properties only. It is clear that "A" asphalts will prolong service life more than "B", and "B" more than "C", but by how much is unknown. Nor do we have, beyond this ranking any estimates of the relative economic benefit of "A" over "B" over "C".

SHRP Objectives

SHRP suggests five projects:

Asphalt Properties

This project will develop a better understanding of the chemical bases of the physical properties and the relationship of these physical properties to asphalt-aggregate systems.

Performance Based Testing and Measuring Systems

This project will identify tests which correlate well with pavement performance. It will be responsible for describing in ASTM/AASHTO format, promising tests and their associated measuring system.

Models to Predict Pavement Performance

Relationships will be developed between asphalt properties and pavement performance using test methods developed in the Performance Based Testing and Measuring Systems project. Performance parameters such as fatigue cracking and permanent deformation will receive special emphasis. Consideration will be given to practicality of the models, reliability of the correlations between physical properties and pavement performance, relative ease of measurement of material properties and inherent variability of test measurements.

Preparation of Performance Based Specifications and an Asphalt-Aggretate Mixtures Analysis System

This project will prepare performance based specifications for asphalt and provide guidelines for the implementation of the Asphalt Aggregate Mixture Analysis System to be developed by NCHRP.

Coordination

The objective of this project is to provide coordination for the other projects, and to operate a "library" of asphalts, aggregates and modifiers for use by contract agencies and other interested and authorized organizations. The project will also oversee the statistical and economic considerations inherent in the other projects as well as the implementation packages in which they will culminate.

C-SHRP Objectives

Asphalts "A", "B" and "C"

In the Winnipeg workshop of Canadian experts, held in November 1985, the major suggestion was to look at the economic benefits of "A" versus "B" versus "C" type asphalts. The asphalt committee also anticipated that SHRP and C-SHRP experience would help us to confirm the relative merits of different types of asphalt.

Monitoring Asphalt Test Sites

Long-term solutions of asphalt pavement test sites will yield the correlation with analytical models and in-service performance.

LONG-TERM PAVEMENT PERFORMANCE TECHNICAL RESEARCH AREA

Introduction

There are many pavement management systems across the United States and Canada, using "models" that fit local presumptions of what pavement behaviour is like. The public has been reasonably well served with quality pavements and access to destinations of its choice but highway agencies have not realized their expectations of pavement life in return for their investment.

SHRP Objective

The SHRP diagnosis of pavement management in North America is outlined above, and SHRP is attempting to cut across the confusion, and build a pavement per-

formance experiment and data base from which a new set of models can be derived.

SHRP General Pavement Studies (GPS)

GPS is a large experimental design, incorporating major independent variables such as environment, pavement type and traffic with a view to explaining the dependent variables, performance and distress, in a full factorial lay-out. It is intended to contain mostly in-service sections.

SHRP Specific Pavement Studies (SPS)

SPS are intensive studies of a few factors of special interest. Some studies may utilize existing pavements, but for the most part, the sections will be designed and built specially for SPS.

C-SHRP Objectives

Test Sites

Under the integral program of C-SHRP, arrangements will be made for Canadian sections to be volunteered to SHRP, and for SHRP results to be relayed to Canadian users.

The SHRP program for Long-Term Pavement Performance monitoring of several categories of pavement design is being extended by the inclusion of Canadian sections appropriate to the SHRP study design. Results for SHRP will indicate how well these Canadian sections fit into the general relationships developed by SHRP. To make full use of the relationships developed by SHRP, a larger monitoring program of Canadian pavement sections incorporating a wider variety of soils and pavement types would be needed.

Bituminous Surface Treatments

To look at the design and performance of bituminous surface treatments under heavy loads.

MAINTENANCE COST EFFECTIVENESS TECHNICAL RESEARCH AREA

Goals of Maintenance (and Rehabilitation)

The goals of road maintenance and rehabilitation are two-fold:

To provide individuals and industry with satisfactory levels of travel costs (e.g. accident costs, journey time and vehicle costs), and travel comfort (e.g. freedom from vehicle vibration and noise), at a price that is acceptable to the highway agency. These satisfactory levels of travel costs and comfort are secured by smoothness of the road and adequate surface friction.

To preserve the equity already built into the road. Timely maintenance will arrest or slow down deterioration of the road structure, and so will defer the need to spend (much larger) reconstruction dollars. The overall "construction-maintenance cost" of the road, over its life-time, is thereby optimized.

Timeliness of maintenance and rehabilitation of our roads is thwarted by budget contraints in both the United States and Canada. The budget constraints are unlikely to go away in the near future. We need to develop ways of doing more within existing budgets, through innovation in:

Engineering -- better use of materials and equipment and improved procedures

Maintenance management -- more efficient ways of measuring cracking, rutting and roughness, better ways of deciding among maintenance and rehabilitation treatments, and of setting priorities over entire highway networks.

SHRP Objectives

SHRP suggests five projects:

Quantifying Pavement Maintenance Effectiveness

This project will create a data base to evaluate the effectiveness of four flexible pavement maintenance treatments and two rigid pavement maintenance treatments in terms of pavement condition improvement and extended life. The data base will include environmental, traffic, pavement characterization and performance information in much the same format as in the long-term pavement performance study.

Measuring Systems and Instrumentation for Evaluating Pavement

This project will identify pavement conditions and contributory factors that must be measured to evaluate pavement maintenance effectiveness. Equipment and methods currently in use will be identified, and where none exists new equipment and methods will be developed. Manuals of instruction will be prepared.

Improved Materials and Equipment for Pavement Surface Repairs and Crack Filling

This project will study the materials, equipment and methods used in patching and in the sealing of pavement joints and cracks, in rigid and flexible pavments, urban and rural situations, under low and high traffic volumes, and in all climatic conditions. The project will seek innovative applications for existing materials, and more productive equipment and procedures.

Pavement Maintenance Work Zone Systems to Improve Worker and Motorist Safety

This project will create procedures to evaluate existing and new traffic control devices. Improvements on current barriers, attenuators and warning systems will be sought. Training guides will be developed.

Media Evaluation and Implementation Research in Highway Maintenance

This project addresses the concern of the maintenance community with getting research results used, drawing on marketing technology to ensure effectiveness in reaching the critical sub-populations among engineering professionals.

C-SHRP Objectives

In the Winnipeg workshop of Canadian experts, held in November 1985, two major areas were identified as complementary to the United States work:

Reducing Shoulder Maintenance and Related Safety, Costs and Liability

"Ravelling" of granular shoulder material at the edge of the pavement was identified as a problem. In severe cases of ravelling, material moves away from the pavement edge, leaving a vertical drop that is very hazardous to the driver who might inadvertently wander close to the edge of pavement. The questions that were raised were:

What materials, equipment and methods would it take to alleviate this wide-spread situation?

What liabilities are incurred by law for accidents resulting from this hazard - from one Canadian jurisdiction to another, and what are the implications for highway engineering, if any?

(The relative cost-effectiveness of paved versus granular shoulders is a question to be answered.)

Reducing Rutting in Flexible Pavements, Safety Implications and Remedial Measures

Rutting occurs in the wheel tracks in flexible pavements. Measurements of these ruts is currently done with straight-edge or levelling rod and flag-persons. These methods are inconvenient and time consuming, and expose technicians to danger from traffic. A more efficient and safe method is needed.

Methods of restoration of the pavement cross-section once rutting has occurred, vary, and yield varying levels of success. Cold planing, heater planing, granular lift and surface treatment and hot mix patching are all methods whose effectiveness has not been documented, and which, therefore, cannot be incorporated into a comprehensive system for improving cost-effectiveness.

Automating Measurement of Pavement Distress

To evaluate the appropriateness of automated measurements of pavement distress across jurisdictions in Canada.

Improved Surface Repairs

To evaluate materials, equipment and methods used in patching and sealing pavement joints and cracks in flexible pavements under a range of traffic volumes, soil and other conditions in the Canadian environment.

PROTECTION OF CONCRETE BRIDGE COMPONENTS TECHNICAL RESEARCH AREA

Introduction

De-icing salt, applied by our winter maintenance crews to the roadway, are the major cause of premature deterioration in our concrete structures. The salt penetrates the conrete to the level of steel reinforcement and initiates corrosion. The products of corrosion exert an expansive pressure on the relatively thin layer of concrete above the reinforcing bar, thereby causing spalling of the concrete. The potential return on any research program which focuses on control of corrosion would be the savings in the large numbers of dollars we spend every year to rehabilitate concrete bridges.

SHRP deals with corrosion-induced distress, but this is not the only mechanism of deterioration. Nor is deterioration of bridge components the only issue relevant to bridges.

SHRP Objectives

The SHRP Research Plan consists of four projects:

Inspection and Assessment of the Physical Condition of Concrete Structures

Several current techniques will be assessed and developed. Field testing will be used to further validate them, before inclusion in a manual of criteria for use, and interpretation of results.

Protection and Rehabilitation by Electrochemical Methods

This project will develop technically and economically feasible methods of protecting and rehabilitating concrete bridge components using electrochemical methods.

Protection and Rehabilitation by other than Electrochemical Methods

This project addresses limitations of conventional bridge protection and rehabilitation techniques.

Methodology for the Protection and Rehabilitation of Existing Bridge Components

This project aims to use the results of the other three projects to build systematic, cost-effective procedures to protect and rehabilitate bridge components.

C-SHRP Objectives

Quantifying Service Life

Quantifying the service life of existing methods of rehabilitation (Canadian methods and conditions on decks, beams, piers and abutments) will be explored.

Economic Feasibility of Making Corrosion Resistant Reinforcing Steel

To carry out an anlysis of the economic feasibility of making corrosion-resistant reinforcing steel.

Load-carrying Capacity

To prepare a synthesis of research on load-carrying capacity of bridges and develop evaluation guidelines.

CEMENT AND CONCRETE TECHNICAL RESEARCH AREA

Introduction

Deterioration of concrete continues to ruin the large investments represented by our bridge and pavement structures. Means must be found to enhance the durability of concrete and thus extend its service life.

There is need, therefore, to develop a program of research which will address the performance problems currently being faced. The program should address primarily the chemistry of cement hydration, the properties of concrete and its performance in the highway environment.

SHRP Objectives

The SHRP Research Plan addresses four major areas:

Chemistry and Physics of Cement and Concrete

This project will develop techniques of controlling the microstructure of the products of hydration in order to extend service life of concrete.

Durability of Concrete

To develop means to increase durability of concrete.

Quality Assurance and Nondestructive Testing

To develop techniques of controlling quality during construction and of non-destructive testing to evaluate the condition of existing structures.

Mechanical Behaviour of Concrete

The focus here is on relatively new developments, e.g. additives, that enhance the behaviour of concrete under traffic loading.

C-SHRP Objectives

Fibre Shotcrete

To explore and document the benefits of using fibre shotcrete and disseminating this information.

Alkali-carbonate Reactivity

To review the state-of-the-art and to develop further theoretical understanding of the mechanism of alkali-carbonate reactivity.

Premium Cement

To develop a cement which, in combination with common aggregates, will produce premium performance in concrete structures.

SNOW AND ICE CONTROL TECHNICAL RESEARCH AREA

Introduction

De-icing chemicals, in particular sodium chloride, have kept our roads passable and safe in winter for commuter, recreational and commercial traffic. But it is known that these chemicals cause damage to vehicles, reinforced concrete bridges, parking garages, groundwater, vegetation and other private property. Several research thrusts have been suggested. They include:

Alternative de-icing chemicals, benign to the environment.

Calcium Magnesium Acetate (CMA) is the front runner among proposed alternatives. FHWA and NCHRP are completing large studies of CMA. The Ministry of Transportation and Communications in Ontario continues to be interested in the pros and cons of this de-icer, and is completing a cost-benefit study for the province. SHRP and C-SHRP await results of these studies.

Preventation of Ice-Pavement Bond

The objective is to investigate the mechanism of bond formation and to apply this knowledge to the development of methods for preventing or modifying the bonding.

Destruction of Ice-Pavement Bond

This research seeks to destroy the bond where it has already formed.

In addition, attention has been paid recently to improving the technology of snow-plows and to the development of maintenance decision systems with pavement surface sensor information and micrometeorological data as input.

SHRP Objectives

The SHRP plan consists of the following projects:

Prevention of Ice-Pavement Bond,

Destruction of Ice-Pavement Bond,

Development of Improved Displacement Plows,

Improved Methods of Controlling Blowing Snow,

Management of Snow and Ice Control Operations (maintenance decision system).

C-SHRP Objectives

Immobilizing De-icing Chemicals on Roadway Surfaces

Ways are sought to immobilize de-icing chemicals by physical or chemical means, so that they remain on the surface until fully "spent", thereby reducing the overall quantity of de-icer necessary to clear the road.

Improved Methods of Controlling Blowing Snow

The objective of this research is to prevent blowing snow from reaching a highway, thus saving on the resources spent removing the accumulation that continues days after the original snow-storm is over.

CHAPTER 3 - INVESTMENT OPTIONS

3.1 INTRODUCTION

This chapter addresses two basic objectives. First the cost-effectiveness of the C-SHRP program is discussed at the Program level and at the Technical Research Area level. Then five "options" are given, by selecting in each case, the best set of projects to meet budget levels ranging from $6,006,500 down to $4,076,500.

3.2 COSTS AND BENEFITS

Conventional cost-benefit analysis attempts to create and evaluate accounts for each of the categories of costs and benefits which are expected to result from the successful completion and implementation of each project in a program. For completeness in the analysis, the likelihood of success of each project would have to be incorporated into the calculations, giving a computed "expected value" of the program.

Information for such a comprehensive analysis of the C-SHRP Complementary Program encompassing all jurisdictions which could gain from each particular project is not available.

In this section, instead, first a sample of arguments is presented from the program or overall level. Then, taking 10 percent of the estimated benefits to the United States from each Technical Research Area - given in the SHRP Overview and Integration Report - some estimates of benefits to Canada are developed.

Arguments at the Program Level

The proponents of the SHRP Program in the United States argue as follows (Canadian Quantities substituted for U.S. ones):

> "This program represents the collected opinions of the best experts in this country in highway engineering and of many important stake-holders in the future of our infrastructure. If we could, with a program so conceived, realise but one percent gain in productivity in our annual highway investment of six billion dollars, (sixty million dollars of savings a year), we will pay for this program more than fifty-fold. With such a gain in productivity, we could resurface 1000 km of two-lane roads, or rebuild 300 bridges or add 1000 km of truck-climbing lanes on some of our long grades on rural highways."

The SHRP Program in the United States is driven in part by the deterioration of the interstate system of highways. One consequence of this deterioration is that the SHRP Program will have to be run in parallel with extensive rehabilitation. In Canada, we have the relative advantage of not having reached that level of deterioration. We have time to develop materials, equipment and procedures, as a result of SHRP and C-SHRP research, before our own roads are due for extensive rehabilitation. This lead time will result in considerable productivity gains.

Arguments at the Technical Research Area Level

Taking 10 percent of the estimated benefits to the United States from each Technical Research Area (T.R.A.) - given in the SHRP Overview and Integration Report, Table 1.1 - yields the following expected benefits to Canada:

Asphalt (T.R.A.)	$10 million per year
Long Term Pavement Performance (T.R.A.)	1 billion
Maintenance Cost Effectiveness (T.R.A.)	15 million per year
Protection of Concrete Bridge Components (T.R.A.)	40 million per year
Cement and Concrete (T.R.A.)	5 million per year
Snow and Ice Control (T.R.A.)	4.5 million per year

Asphalt T.R.A.

Objective

Define chemical and physical characteristics of asphalt and their relationship to performance in pavement systems.

Potential Benefits

Better quality control and better materials; and improved design capability and performance predictions. Potential saving of $10 million per year.

Long Term Pavement Performance T.R.A.

Objective

Assess long-term performance of various pavements under various loading and environmental conditons. (Studies would continue for three additional 5-year terms of data collection and analysis).

Potential Benefits

New capability to assess and select alternative pavement maintenance and rehabilitation strategies; and improved design and construction techniques. Potential saving of $1 billion.

Maintenance Cost Effectiveness T.R.A.

Objective

Develop improved procedures for administering and controlling maintenance programs; develop new processes, equipment, and materials; and improve productivity of maintenance program.

Potential Benefits

New management systems and increased maintenance productivity. Potential saving of $15 million per year.

Protection of Concrete Bridge Components T.R.A.

Objective

Develop new methods to stop further deterioration of existing chloride-contaminated bridge decks and other components.

Potential Benefits

More effective techniques for removing chloride from concrete or protecting concrete from chloride contamination? Potential saving of $40 million per year.

Cement and Concrete T.R.A.

Objective

Understand chemical and physical phenomenon of hydration; evaluate new options such as recycled concrete and energy saving components; and develop nondestructive testing methods.

Potential Benefits

Ability to produce a better quality and more durable concrete. Potential saving of $5 million per year.

Snow and Ice Control T.R.A.

Objective

Reduce the use of salt through management techniques and optimum use of mechanical or thermal removal plus alternative chemicals.

Potential Benefits

Reduction in corrosion and environmental problems without a reduction in the level of service of snow and ice control programs. For example, potential savings from a decrease in automobile corrosion could be 4.5 million per year.

3.3 OPTIONS

Twenty-one priority ratings of the "core" C-SHRP Complementary projects were obtained from provincial representatives and members of the Council on Highway Transportation Research and Development (CHTRD) after the second draft of the C-SHRP Report was circulated for review and comments. After minor modifications by the executive of the Council, the following order of the 19 projects was developed.

Project No.	Project Title	Project Cost
1) A-1	Further Monitoring of the Vehicle Weights and Dimensions Test Sites	$ 175,000
2) C-3	Corrective Measures for Ruts in Flexible Pavements	$ 50,000

3)	B-1	Continual Observation of Pavement Performance	$ 500,000
4)	C-4	Improved Materials and Equipment for Pavement Surface Repairs and Crack Filling	$ 300,000
5)	A-2	Pavement Performance Evaluation of A,B,C Quality Asphalts	$ 164,000
6)	D-1	To Quantify the Service Life of Existing Canadian Methods of Protection and Rehabilitation on Decks, Beams, Piers and Abutments	$ 300,000
7)	B-2	Design Method for Bituminous Surface Treatment	$ 600,000
8)	F-1	(Buying into) Snowdrifting/Blowing Project	$ 80,000
9)	A-3	Field Verification of Laboratory Results on A,B,C Quality Asphalts	$ 150,000
10)	C-1	Removal of Hazards due to Ravelling of Granular Shoulder Material at Edge of Pavement	$ 130,000
11)	F-2	Expert System to Combine Snowdrifting Control and Geometric Design Constraints	$ 60,000
12)	D-3	Synthesis of Research on Load-carrying Capacity of Bridges into Evaluation Guidelines	$ 120,000
13)	E-1	Fibre Shotcrete	$ 150,000
14)	D-2	Economic Feasibility of Making Corrosion-Resistant Reinforcing Steel	$ 60,000
15)	B-3	The Effects of Very Heavy Loads on BST	$ 250,000
16)	F-3	Immobilizing Deicing Chemicals	$ 30,000
17)	C-2	Demonstration of Technology to Automate the Measurement of Pavement Distress	$ 100,000
18)	E-3	Development of Premium Cement	$ 500,000
19)	E-2	Alkali-carbonate Reactivity	$ 300,000

From this list, five options were considered. Option 1 was the result of assuming that all projects would be funded. Options 2, 3, 4 and 5 were developed, in turn, by selecting the best projects from the previous option to meet total C-SHRP expenditures set from about $6 million down to about $4 million in steps that were as nearly equal as they could be made without terminating projects before completion.

These options are shown on the following pages, with notes to indicate the loss to productivity that would be sustained as a result of such budgeting strategies.

OPTION 1

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2	150	200	100	100	50	600	2089	4076.5
8) F-1	80					80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1		60	50	20		130	2449	4436.5
11) F-2		20	20	20		60	2509	4496.5
12) D-3		30	30	30	30	120	2629	4616.5
13) E-1		50	50	50		150	2779	4766.5
14) D-2		30	30			60	2839	4826.5
15) B-3		75	75	50	50	250	3089	5076.5
16) F-3			30			30	3119	5106.5
17) C-2			100			100	3219	5206.5
18) E-3			75	225	200	500	3719	5706.5
19) E-2			70	70	160	300	4019	6006.5
	714	845	855	890	715	4019		

The total cost for doing all 19 projects of the Complementary Program would amount to $ 4,019,000. The cost of the other components of C-SHRP (Monitoring, Technology Transfer, Integral and Coordinator), amounts of $ 1,987,500. The overall total of C-SHRP would be $ 6,006,500.

These 19 projects of the Complementary Program represent the "core" of all of the projects considered. They have undergone a thorough review and analysis by Canadian transportation experts. Dropping any of these projects will result in losses of productivity and an incomplete strategic program.

OPTION 2

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2	150	200	100	100	50	600	2089	4076.5
8) F-1		80				80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1			60	50	20	130	2449	4436.5
11) F-2			20	20	20	60	2509	4496.5
12) D-3		30	30	30	30	120	2629	4616.5
13) E-1			50	50	50	150	2779	4766.5
14) D-2				30	30	60	2839	4826.5
15) B-3		75	75	50	50	250	3089	5076.5
16) F-3			30			30	3119	5106.5
17) C-2				100		100	3219	5206.5
	634	765	690	655	475	3219		

This option would result in the loss of projects E-3: Development of Premium Cement and E-2: Alkali-carbonate and other reactivity problems. This loss would mean having to forego potential advances to the state-of-the-art in cement and concrete technology, and in turn, to the technology of building longer lasting concrete bridges and pavements. If one bridge was to be saved by such an advance in the state-of-the-art, then these project costs will have been well invested.

Consequences

* Loss of opportunity to extend life of structures.

OPTION 3

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2	150	200	100	100	50	600	2089	4076.5
8) F-1		80				80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1			60	50	20	130	2449	4436.5
11) F-2			20	20	20	60	2509	4496.5
12) D-3		30	30	30	30	120	2629	4616.5
13) E-1			50	50	50	150	2779	4766.5
14) D-2				30	30	60	2839	4826.5
	634	690	585	505	425	2839		

This option would result in the further loss of projects B-3: The Effects of Very Heavy Loads on BST; F-3: Immobilizing De-icing Chemicals; and C-2: Demonstration of Technology to Automate the Measurement of Pavement Distress .

BST is used as a low-cost alternative surfacing strategy when traffic is low. This technology has widespread application to low volume provincial and municipal roads. The loss of an opportunity to explore the impact of heavy trucks will leave uncertainty about what to expect whenever such traffic occurs.

Not exploring the possibility of immobilizing de-icing chemicals will mean a loss of a chance to reduce the amount of de-icing chemicals used and the considerable damage to the environment caused by such use. Reducing the number of applications of deicing chemicals will enhance safety.

The loss of the project to demonstrate automated pavement distress assessment would mean loss of potential to replace inconvenient, time consuming and hazardous normal methods. It will also result in the Canadian loss of the current "technology edge" it has in this area.

Consequences

- Loss of opportunity to reduce maintenance costs and environmental damage,
- Safety,
- Poor pavement management practices and recognition of problem areas,
- Loss of current "technology edge".

OPTION 4

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1	100	100	100			300	1489	3476.5
7) B-2		150	200	125	125	600	2089	4076.5
8) F-1					80	80	2169	4156.5
9) A-3		60	30	30	30	150	2319	4306.5
10) C-1			60	50	20	130	2449	4436.5
	484	530	585	400	450	2449		

This option would result in the further loss of projects F-2: Expert System to Combine Snowdrifting Control and Geometric Design Constraints; D-3: Synthesis of Research of Load-carrying Capacity of Bridges into Evaluation Guidelines; E-1: Fibre Shotcrete; and D-2: Economic Feasibility of Making Corrosion-resistant Reinforcing Steel.

The loss of the project to develop an expert system would mean failure to transfer our technology as fully as possible.

The loss of research on load-carrying capacity of bridges would mean continued lack of unified bridge evaluation methods.

The loss of the opportunity to document the advantages of fibre shotcrete to substructures rehabilitation and stabilization of rock cuts would mean that the majority of jurisdictions in Canada would lose some of the potential for producing gain inherent in its use.

The loss of the project to investigate corrosion-resistant steel will mean that the potential for spending less on this large-volume item will be lost.

Consequences

- Overdesign and underutilization of bridges,
- Safety,
- Loss of opportunity to reduce costs of winter maintenance,
- Reduction in longevity of structures.

OPTION 5

C-SHRP COMPLEMENTARY PROGRAM BUDGET ALLOCATIONS

in thousands of dollars $(000)

Project No.	YR.1	YR.2	YR.3	YR.4	YR.5	Proj. Total	Cumul. Total	C-SHRP Cumul. Total
1) A-1	35	35	35	35	35	175	175	2162.5
2) C-3	25	25				50	225	2212.5
3) B-1	100	100	100	100	100	500	825	2712.5
4) C-4	60	60	60	60	60	300	1025	3012.5
5) A-2	164					164	1189	3176.5
6) D-1		100	100	100		300	1489	3476.5
7) B-2		150	200	125	125	600	2089	4076.5
	384	470	495	420	320	2089		

This option would result in the further loss of projects F-1: (Buying into) Snowdrifting/Blowing Project; A-3: Field Verification of Laboratory Results on A,B,C Quality Asphalts; and C-1: Removal of Hazards due to Ravelling of Granular Shoulder Material at Edge of Pavement.

The loss of the project on blowing snow could mean that jurisdictions with this problem would continue to have blocked roads and safety hazards.

The loss of project A-3 would mean the incomplete use of the results of A-2.

The loss of the project on ravelling could mean combined hazard, expense and liability in the courts for injury and property damage.

Consequences

- Decreased safety,
- Increased maintenance costs,
- Failure to fully benefit from investment in previous project.

C-SHRP

Program Budget Overview

Year	0	1	2	3	4	5	6	7	Total
Coordinator	70k	70k	70k	70k	70k	70k	70k	30k	520k
ITEM									
(A) Monitoring									
Information Management System		75k	45k	40k	40k	30k	-	-	230k
Newsletters		7.5k	7.5k	7.5k	7.5k	7.5k	-	-	37.5k
Seminars		20k	20k	20k	20k	20k	-	-	100k
(B) Technology Transfer									
Cluster 1 (Pavements)									
Cluster 2 (Structures)		0	50k	100k	120k	130k	80k	30k	510k
Cluster 3 (Snow & Ice)									
(C) Integral Program									
AVC/WIM Equipment		45k	45k	0	0	0	-	-	90k
Loaned Staff		100k	100k	100k	100k	100k			500k
(D) Complementary Program									
Option 1		714k	845k	855k	890k	815k	-	-	4019k
Option 2		634k	765k	690k	655k	475k	-	-	3219k
Option 3		634k	690k	585k	505k	425k	-	-	2839k
Option 4		484k	530k	585k	400k	450k	-	-	2449k
Option 5		384k	470k	495k	420k	320k	-	-	2089k
Totals									
Option 1	70k	1031.5k	1182.5k	1192.5k	1247.5k	1072.5k	150k	60k	6006.5k
Option 2	"	951.5k	1102.5k	1027.5k	1012.5k	832.5k	"	"	5206.5k
Option 3	"	951.5k	1027.5k	922.5k	862.5k	782.5k	"	"	4826.5k
Option 4	"	801.5k	867.5k	922.5k	757.5k	807.5k	"	"	4436.5k
Option 5	"	701.5k	807.5k	832.5k	777.5k	677.5k	"	"	4076.5k

CHAPTER 4 - C-SHRP ORGANIZATION AND MANAGEMENT

4.1 INTRODUCTION

It is proposed that the Canadian Strategic Highway Research Program operate under an Executive Committee of C-SHRP which reports directly to the Roads and Transportation Association of Canada's Board of Directors. This C-SHRP Executive Committee would consist of three representatives from the Council on Highway and Transportation Research and Development and three representatives from Technical Council. The Director of RTAC's Technical Programs would be an ex-officio member of this Executive Committee. A member of the Board of Directors would be appointed as chairman of this committee. This group would be responsible for providing policy guidance for the entire program, providing overview guidance to the technical program and making recommendations to the RTAC Board of Directors.

The execution of C-SHRP would fall under the guidance of the C-SHRP national coordinator. The C-SHRP regional coordinators would form the Technical Steering Committee, which would provide technical direction and oversight. This steering committee would operate under the policies and directives of the Executive Committee and be responsible for administrative and technical overview of the program. It would also ensure that the C-SHRP technical research objectives are accomplished in a timely manner and ensure early dissemination of research findings. The steering committee would have overall responsibility for the four C-SHRP program groups. These groups include:

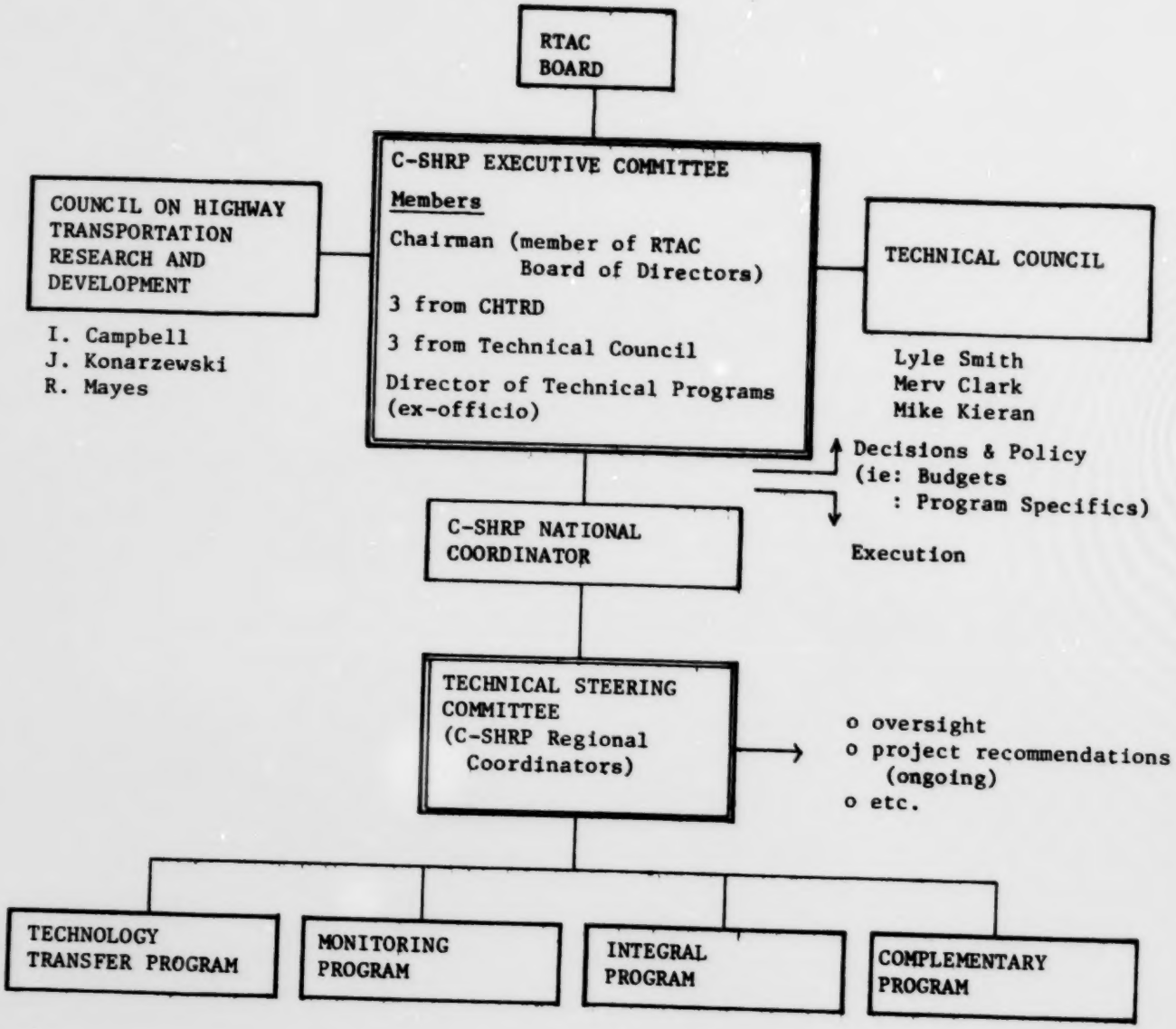
1. Technology Transfer Program
2. Monitoring Program
3. Integral Program
4. Complementary Program.

A mid-program review will be scheduled to look at progress of all aspects of C-SHRP. To facilitate this, each component must carry out their review, evaluation and recommendations. The Executive Committee will make final recommendations to the RTAC Board of Directors.

4.2 ORGANIZATION CHART

See next page.

C-SHRP ORGANIZATION CHART



APPENDIX "A"

- LIST OF DELEGATES AT WINNIPEG WORKSHOP NOVEMBER, 1985
- REGIONAL COORDINATORS OF C-SHRP
- CHTRD MEMBERSHIP LIST

List of Delegates at Winnipeg Workshop
November 1985

Group A - Asphalt Properties

Richard Langlois (Chairman)	Quebec Ministry of Transport, Quebec
Nabil Kamel	Petro Canada, Sheridan Park
Norman McLeod	McAsphalt, West Hill
Harold Eley	Saskatchewan Highways & Transportation, Regina
Warren Robertson	Imperial Oil, Sarnia
Jim Howarth	Chevron Asphalt, Vancouver
John Emery	Trow Ltd., Brampton

Group B - Long Term Pavement Performance

Tom Christison (Chairman)	Alberta Research Council, Edmonton
Bill Phang	Ontario Ministry of Transportation & Communications, Downsview
Garry Heiman	Saskatchewan Highways and Transportation, Regina
Fred Young	Manitoba Highways & Transportation, Winnipeg
Frank Gervais	Nova Scotia Department of Transportation, Halifax
Keith Hicks	New Brunswick Department of Transportation, Fredericton
Tom Jenson	Canadian Trucking Association, Winnipeg
Pierre Boucher	Transport Canada, Ottawa
Eric Theriault	Newfoundland Department of Transportation, St. John's
Gerry Smith	UMA Engineering Limited, Winnipeg

Group C - Maintenance Cost Effectiveness

Lyle Smith (Chairman)	New Brunswick Department of Transportation, Fredericton
George Vincent	Alberta Transportation, Edmonton
Rex Porter	Ontario Ministry of Transportation & Communications, Downsview
Alain Vallières	Quebec Ministry of Transport, Quebec
John F. O'Reilly	Newfoundland Department of Transportation, St. John's
Barry Rowley	Manitoba Highways & Transportation, Winnipeg
Marc Brenckmann	Transport Canada, Ottawa

Group D -- Bridge Protection

Dave Marett (Chairman)	Regional Municipality of Ottawa-Carleton
Jacques Beauchamp	Public Works Canada, Ottawa
M. Magued	Morrison Hershfield Limited, North York
Lorne Hamblin	Saskatchewan Highways & Transportation, Regina
Dave Manning	Ontario Ministry of Transportation & Communications, Downsview
Ian Campbell	Ontario Ministry of Transportation & Communications, Downsview

Group E -- Cement and Concrete

Peter Smith (Chairman)	Ontario Ministry of Transportation & Communications, Downsview
John Bickley	Trow Limited, Brampton
Lorne Dixon	Alberta Transportation, Edmonton
Pierre La Fontaine	Quebec Ministry of Transport, Quebec
Phil Pearson	Saskatchewan Highways & Transportation, Regina
Gerry Allen	Canadian Portland Cement Association, Ottawa

Group F - Snow and Ice Control

Joe Gruspier (Chairman)	Ontario Ministry of Transportation & Communications, Downsview
I.R.G. Lowe	National Research Council, Ottawa
Barry Tinkler	Manitoba Highways & Transportation, Winnipeg
Terry Peel	Domtar, Senneville
Bill Rowan	Morrison Hershfield Limited, North York
Rick Godding	Canadian Automobile Association, Ottawa
Jan Konarzewski	Alberta Transportation, Edmonton
Charles James	RTAC, Ottawa

Unassigned Invitees

Boris Hryhorczuk	Deputy Minister, Manitoba Highways & Transportation, Winnipeg
Bev Hamm	Deputy Minister, Nova Scotia Department of Transportation, Halifax
Albert Stevens	Chairman, CHTRD, University of New Brunswick, Fredericton
Jack Peacock	Assistant Deputy Minister, Manitoba Highways & Transportation, Winnipeg
John Robinson	RTAC, Ottawa
John E. Hill	RTAC, Ottawa
N. Brown	RTAC, Ottawa

Regional Coordinators of C-SHRP

J.E. Hill (RTAC Coordinator)	RTAC, Ottawa
M.G.E. Elston	B.C. Ministry of Transportation & Highways, Victoria
J.Z. Konarzewki	Alberta Transportation, Edmonton
A.T. Horosko	Saskatchewan Highways & Transportation, Regina
F.D. Young	Manitoba Highways & Transportation, Winnipeg
I.C. Campbell	Ontario Ministry of Transportation & Communications, Downsview
Richard Langlois	Quebec Ministry of Transport, Quebec
Keith Hicks	New Brunswick Department of Transportation, Fredericton
E.A. King	Nova Scotia Department of Transportation, Halifax
Michael J. Bailey	P.E.I. Transportation & Public Works, Charlottetown
Terrence McCarthy	Newfoundland Department of Transportation, St. John's
D.T. Campbell	Department of Community & Transportation Services, Whitehorse

CHTRD Membership List

I.C. Campbell (Chairman)	Ontario Ministry of Transportation & Communications, Downsview
J.Z. Konarzewski	Alberta Transportation, Edmonton
A.M. Stevens	University of New Brunswick, Fredericton
John Robinson	RTAC, Ottawa
M.J. Bailey	P.E.I. Transportation & Public Works, Charlottetown
W.T. Beckett	Newfoundland Department of Transportation St. John's
Norman Clark	Motor Vehicle Manufacturers' Association, Toronto
Ed Cuylits	Regional Industrial Expansion, Ottawa
D.C.S. Edwards	Canadian Bus Association, Ottawa
M.G.E. Elston	B.C. Ministry of Transportation & Highways, Victoria
R. Godding	Canadian Automobile Association, Ottawa
Keith Hicks	New Brunswick Department of Transportation Fredericton
A.T. Horosko	Saskatchewan Highways & Transportation, Regina
Tom Jenson	Kleysen Transport Limited, Winnipeg
M.E. Kieran	Peat, Marwick & Partners, Montreal
Paul Landry	Saskatchewan Highway Traffic Board, Regina
Christian Lardinois	University of Montreal
R.E. Leveque	Petro-Canada Products, Sheridan Park
R.R. Mayes	Transport Canada, Ottawa
Jack Peacock	Manitoba Highways & Transportation, Winnipeg
Heinz Schweinbenz	The Hamilton Street Railway Company, Hamilton
D.L. Stonehouse	Nova Scotia Department of Transportation, Halifax
Gérard Tessier	Quebec Ministry of Transport, Quebec
S.C. Wilson	Transport Canada, Ottawa
Neil S. Wither	Red River Construction Ltd., Winnipeg
Henry Wittneberg	Canadian Truck Trailer Manufacturers' Association, Kleinberg

APPENDIX "B"

TECHNOLOGY TRANSFER PROJECT STATEMENTS

- PAVEMENTS RELATED CLUSTER
- STRUCTURES RELATED CLUSTER
- SNOW AND ICE CONTROL CLUSTER

PROJECT # AREA 1

C-SHRP TECHNICAL RESEARCH AREA

Pavement Related Area

(a) Asphalt; (b) Long Term Pavement Performance; (c) Maintenance Cost Effectiveness

PROJECT TITLE

Incorporation of Findings of SHRP and C-SHRP Research on (a) Asphalt into Canadian Design, Construction and Quality Control Procedures, (b) GPS and SPS into Canadian Pavement Management Systems and (c) Maintenance Cost-effectiveness into Canadian Maintenance Procedures.

PROBLEM STATEMENT/BACKGROUND

As milestones are reached in the SHRP and C-SHRP research on asphalt, long term pavement performance and maintenance cost effectiveness there will be need for

1) technology transfer to help individual Canadian jurisdictions to recognize the implications for their own design, construction and quality control procedures;

2) modifications, in the later years of the five-year horizon, of the C-SHRP Research Program, in the light of new knowledge.

These goals cannot be achieved if RTAC acts simply as a clearing house for interim reports. An expert should be retained to interpret interim findings, screen them for potential benefit to Canadian jurisdictions, and then relay them in the format(s) conducive to the realization of full benefit.

OBJECTIVE/SCOPE

The expert with the guidance of a steering committee writes at least one updated state-of-the-art report a year for each of the six years, identifies opportunities within Canadian jurisdictions for implementation, and proposes updates to the C-SHRP Research Program in the light of new knowledge. The expert must be kept fully informed of all related research and design an appropriate technology transfer package.

TARGETED PRODUCTS

See OBJECTIVE/SCOPE above.

RATIONALE FOR INCLUSION IN C-SHRP

Engineers in provincial highway agencies and municipalities will not necessarily be able to free resources for interpretation and synthesis of SHRP

and C-SHRP work on all the tasks in these Technical Research Areas. A central, cooperative project in which one researcher does this for all of Canada is cheaper and ensures continuity and non-duplication. It provides for a central organization and ensures effective technology transfer.

This project is included as a separate section entitled Technology Transfer because of its importance in making sure the appropriate research is put into practice at the earliest date.

LINKAGES

Directly links SHRP results and Canadian users. Updates C-SHRP plan.

PRELIMINARY PROJECT DESIGN

Expert reports to an RTAC steering committee.

Expert gets to know the state of pavement technology from jurisdiction to jurisdiction and the work in the SHRP research tasks in order to make the right connections.

TIMING REQUIREMENTS

Year 2 to year 7 of the C-SHRP.

COST ESTIMATES

6 years for a total of $204,000.00

PROJECT # AREA 2

C-SHRP TECHNICAL RESEARCH AREA

Structures Related Area

(a) Protection of Concrete Bridge Components
(b) Cement and Concrete Technology

PROJECT TITLE

Incorporation of Findings of SHRP and C-SHRP Research on (a) Concrete Bridge Proection and (b) Cement and Concrete Technology into Canadian practice.

PROBLEM STATEMENT/BACKGROUND

As milestones are reached in the SHRP and C-SHRP research on Concrete Bridge Protection, and Cement and Concrete Technology there will be need for

1) technology transfer to help individual Canadian jurisdictions to recognize the implications for their own bridge evaluation and protection procedures;

2) modifications, in the later years of the five-year horizon, of the C-SHRP Research Program, in the light of new knowledge.

These goals cannot be achieved if RTAC acts simply as a clearing house for interim reports. An expert should be retained to interpret interim findings, screen them for potential benefit to Canadian jurisdictions, and then relay them in the format(s) conducive to the realization of full benefit.

OBJECTIVE/SCOPE

The expert with the guidance of a steering committee writes at least one updated state-of-the-art report a year for each of the six years, identifies opportunities within Canadian jurisdictions for implementation, and proposes updates to the C-SHRP Research Program in the light of new knowledge. The expert must be kept fully informed of all related research and design an appropriate technology transfer package.

TARGETED PRODUCTS

See OBJECTIVE/SCOPE above.

RATIONALE FOR INCLUSION IN C-SHRP

Engineers in provincial highway agencies and municipalities will not necessarily be able to free resources for interpretation and synthesis of SHRP

and C-SHRP work in these Technical Research Areas which pertains to some of their heaviest investments in highway infrastructure. A central, cooperative project in which one researcher does this for all of Canada is cheaper and ensures continuity and non-duplication.

This project is included in the Technology Transfer section rather than in the Monitoring Program because of the intensity of focus that will be required to do a good job of technology transfer.

LINKAGES

Directly links SHRP results and Canadian users. Updates C-SHRP plan.

PRELIMINARY PROJECT DESIGN

Expert reports to an RTAC steering committee.

Expert gets to know the Canadian bridge-protection scene and state of the art in cement and concrete technology from jurisdiction to jurisdiction, as well as the SHRP research in this area, in order to make the right connections.

TIMING REQUIREMENTS

Year 2 to year 7 of the C-SHRP.

COST ESTIMATES

6 years for a total of $204,000.00

PROJECT # AREA 3

C-SHRP TECHNICAL RESEARCH AREA

Snow and Ice Control

PROJECT TITLE

Incorporation of Findings of SHRP and C-SHRP Research on Snow and Ice Control into Canadian practice.

PROBLEM STATEMENT/BACKGROUND

As milestones are reached in the SHRP and C-SHRP research on Snow and Ice Control, there will be need for

1) technology transfer to help individual Canadian jurisdictions to recognize the implications for their own procedures;

2) modifications, in the later years of the five-year horizon, of the C-SHRP Research Program, in the light of new knowledge.

These goals cannot be achieved if RTAC acts simply as a clearing house for interim reports. An expert should be retained to interpret interim findings, screen them for potential benefit to Canadian jurisdictions, and then relay them in the format(s) conducive to the realization of full benefit.

OBJECTIVE/SCOPE

The expert with the guidance of a steering committee writes at least one updated state-of-the-art report a year for each of the six years, identifies opportunities within Canadian jurisdictions for implementation, and proposes updates to the C-SHRP Research Program in the light of new knowledge. The expert must be kept fully informed of all related research and design an appropriate technology transfer package.

TARGETED PRODUCTS

See OBJECTIVE/SCOPE above.

RATIONALE FOR INCLUSION IN C-SHRP

Road-way maintenance engineers in provincial highway agencies and municipalities will not necessarily be able to free resources for interpretation and synthesis of SHRP work in this Technical Research Area. A central, cooperative project in which one researcher does this for all Canada is cheaper and ensures continuity and non-duplication.

This project is included in the Technology Transfer section rather than in the Monitoring Program because of the intensity of focus that will be required to do a good job of technology transfer.

LINKAGES

Directly links SHRP results and Canadian users. Updates C-SHRP plan.

PRELIMINARY PROJECT DESIGN

Expert reports to an RTAC steering committee.

Expert gets to know the state-of-the-art in snow and ice control from jurisdiction to jurisdiction in Canada, as well as the SHRP research in this area, in order to make the right connections.

TIMING REQUIREMENTS

6 years from year 2 to year 7 of C-SHRP.

COST ESTIMATES

6 years for a total of $102,000.00

APPENDIX "C"

COMPLEMENTARY PROJECT STATEMENTS

- ASPHALT
- LONG TERM PAVEMENT PERFORMANCE
- MAINTENANCE COST EFFECTIVENESS
- CONCRETE BRIDGE COMPONENTS
- CEMENT AND CONCRETE
- SNOW AND ICE CONTROL

SUMMARY OF COST ESTIMATES OF PROJECTS

Asphalt				
A-1	:	Further Monitoring of the Vehicle Weights and Dimensions Test Sites	$175,000	
A-2	:	Pavement Performance Evaluation of A, B, C Quality Asphalts	$164,000	
A-3	:	Field Verification of Laboratory Results on A, B, C Quality Asphalts	$150,000	
				$489,000
Long-term Pavement Performance				
B-1	:	Continual Observation of Pavement Performance	$500,000	
B-2	:	Design Method for Bituminous Surface Treatment	$600,000	
B-3	:	The Effects of Very Heavy Loads on BST	$250,000	
				$1,350,000
Maintenance Cost-effectiveness				
C-1	:	Removal of Hazards due to Ravelling of Granular Shoulder Material at Edge of Pavement	$130,000	
C-2	:	Demonstration of Technology to Automate the Measurement of Pavement Distress	$100,000	
C-3	:	Corrective Measures for Ruts in Flexible Pavements	$ 50,000	
C-4	:	Improved Materials and Equipment for Pavement Surface Repairs and Crack Filling	$300,000	
				$580,000

Concrete Bridge Components				
D-1	:	To Quantify the Service Life of Existing Canadian Methods of Protection and Rehabilitation on Decks, Beams, Piers and Abutments	$300,000	
D-2	:	Economic Feasibility of Making Corrosion Resistant Reinforcing Steel	$ 60,000	
D-3	:	Synthesis of Research on Load-Carrying Capacity of Bridges into Evaluation Guidelines	$120,000	
				$480,000
Cement and Concrete Technology				
E-1	:	Fibre Shotcrete	$150,000	
E-2	:	Alkali-Carbonate and other Reactivity Problems	$300,000	
E-3	:	Development of Premium Cement	$500,000	
				$950,000
Snow and Ice Control				
F-1	:	(Buying into) Snowdrifting/ Blowing Project	$ 80,000	
F-2	:	Expert System to Combine Snowdrifting Control and Geometric Design Constraints	$ 60,000	
F-3	:	Immobilizing Deicing Chemicals	$ 30,000	
				$170,000
				$4,019,000

Projects Addressing Innovation in Asphalt Technology

PROJECT # A-1

C-SHRP TECHNICAL RESEARCH AREA

Asphalt pavements

PROJECT TITLE

Further Monitoring of the Vehicle Weights and Dimensions Test Sites

PROBLEM STATEMENT/BACKGROUND

Under the sponsorship of the Vehicle Weights and Dimensions Study instrumentation to measure pavement strains and deflections has been built into new pavement sections at 13 sites across Canada. A substantial field test program was carried out to measure pavement strains and deflections under different axle loads and configurations was carried out, but there is much greater benefit to be obtained through continued measurements at these sites as the pavements age. The Pavements Advisory Committee has recommended that further research be considered at these sites in order to exploit fully their potential. To date, over $500,000 has been invested in preparing and testing at these sites, and significant additional benefits would be realized through conduct of additional nationally coordinated research initiatives.

OBJECTIVE/SCOPE

To use the relationships between strains and deflections and time at the Vehicle Weights and Dimensions test sites to develop insights into areas such as -

- load equivalency factors for axle configurations other than those investigated in the Vehicle Weights and Dimensions project
- the relationship between pavement strain and deflection and long term performance
- the "fourth power law" in assessing fatigue life
- seasonal effects (e.g. spring thaw) on pavement strain and deflection
- the effects of different tire types and pressures on pavement response
- the effects of aging on pavement response

TARGETED PRODUCTS

Data bank, analysis and report(s) on a selected subset of areas identified under Objective/Scope above.

RATIONALE FOR INCLUSION IN C-SHRP

Suggestion from the Pavements Advisory Committee

LINKAGES

To SHRP Long-Term Pavement Performance Technical Research Area and to C-SHRP project on Continual Observation of Pavement Performance.

PRELIMINARY PROJECT DESIGN

Data on strains and deflections will be monitored and assembled by a contractor reporting to a project steering committee. Reports will be written on a subset of issues identified above, and as directed by the steering committee.

TIMING REQUIREMENTS

About 1 month per year for 5 years.

COST ESTIMATES

$175,000 over 5 years.

PROJECT # A-2

Reference: Unsolicited Proposal to RTAC from Nabil Kamel of Petro-Canada

C-SHRP TECHNICAL RESEARCH AREA

Asphalt

PROJECT TITLE

Pavement Performance Evaluation of A, B, C Quality Asphalts

PROBLEM STATEMENT/BACKGROUND

A new asphalt cement quality grade standard (A, B, C) is expected to be introduced by the Canadian General Standard Board (CGSB). The A, B or C quality is determined by standard tests of physical properties only. It is clear that A asphalts will prolong service life more than B asphalts, and B more than C, but by how much is unknown. Lacking this information, we cannot estimate relative economic benefit of A over B over C.

OBJECTIVE/SCOPE

A, B, C Quality Effects.

Crude Source and Manufacturing Process Effects.

Penetration Grade Effects.

TARGETED PRODUCTS

Information on the relative performance of A, B, C Quality asphalts.

Preliminary design guidelines for different quality asphalts over a wide range of traffic loads and climate.

RATIONALE FOR INCLUSION IN C-SHRP

The SHRP Program will probably include A, B and C asphalts of interest to Canada, but not all. In a Canadian program we would ensure that samples are obtained from all Canadian sources, including those least likely to be tested in SHRP (A asphalts). By doing this project we would be able to provide SHRP with the opportunity to corroborate their results.

LINKAGES

Commonality of need among provinces and Yukon Territory.

Related to SHRP Projects 1, 2, 3, 4.

A-2

PRELIMINARY PROJECT DESIGN

1. Design an experimental program to examine the effects of sources, manufacturing processes, A, B and C quality standards, and penetration on pavement performance.

2. Characterize selected asphalt cements for physical properties, temperature susceptibility and chemical composition.

3. Determine all Marshall properties on designs using typical hot-mix aggregates.

4. Carry out life-cycle simulation using test models and full-scale dynamic loading, and evaluate fatigue, rutting and aging characteristics and transverse deformation due to traction.

5. Analyze physical data, do economic analyses and write preliminary design guidelines.

6. Identify asphalts and pavement designs for field trials to confirm laboratory results.

TIMING REQUIREMENTS

Twelve months.

If we were to start immediately, there would be greater duplication between SHRP and C-SHRP, but - as a result - increased confidence in the application of all the SHRP findings not included in C-SHRP. Even if we were to wait one year for SHRP to identify asphalts in their program, we would still design into our program some duplication in order to corroborate SHRP results for our testing environment and asphalt cement sources.

In addition, delays in Project A-2 will advance the starting date of Project A-3, Field Verification of Laboratory Results in "A", "B" and "C" Quality Asphalts, slated to take five to seven years. Any delay, therefore, will likely extend the C-SHRP Complementary Program.

COST ESTIMATES

1.	Determine A, B, C Quality Effects	$ 72,000
2.	Determine Source and Manufacturing Process Effects	$ 50,000
3.	Determine Penetration Grade Effects	$ 42,000
	Total	$164,000

PROJECT # A-3

Reference: Unsolicited Proposal to RTAC from Nabil Kamel of Petro-Canada

See also Project A-2 in this report

PROJECT TITLE

Field Verification of Laboratory Results on A, B, C Quality Asphalts

PROBLEM STATEMENT/BACKGROUND

The reference proposal and Project A-2 of this report address the development of preliminary design guidelines based on laboratory simulation of traffic loading on pavement structures. Field validation is necessary before the guidelines can be finalized.

OBJECTIVE/SCOPE

It is hoped that sections of highway that are being built anyway will constitute the 'experiment' for this project. Long-term observations will yield the necessary correlations with laboratory results.

TARGETED PRODUCTS

Final, field-validated design guidelines.

RATIONALE FOR INCLUSION IN C-SHRP

This area was identified by experts at the Winnipeg workshop. Logical follow--up to Project A-2.

This project is necessary for full realization of benefits from project A-2, Pavement Performance Evaluation of A, B and C Quality Asphalts.

LINKAGES

Uniquely Canadian need -- A, B, C unique to Canada.

Related to SHRP Projects 1, 2, 3, 4.

PRELIMINARY PROJECT DESIGN

Advantage will be taken of pavements built with mix designs similar to those in Project A-1. Long-term field observations will be correlated with laboratory results, and long-term distress and performance equations developed.

TIMING REQUIREMENTS

Five years.

This project will have to follow Project A-2, Pavement Performance Evaluation of A, B and C Quality Asphalts or a minimum program of corroboration of U.S. laboratory results.

COST ESTIMATES

Not including test roads: $150,000.

Projects Addressing Long-term Pavement Performance

PROJECT # B-1

C-SHRP TECHNICAL RESEARCH AREA

Long-term Pavement Performance

PROJECT TITLE

Continual Observation of Pavement Performance

PROBLEM STATEMENT/BACKGROUND

The SHRP program for Long-term Pavement Performance monitoring of several categories of pavement design is being extended by the inclusion of Canadian sections appropriate to the SHRP study design. Results from SHRP will indicate how well these Canadian sections fit into the general relationships developed by SHRP. To make full use of the relationships developed by SHRP, a larger monitoring program of Canadian pavement sections incorporating a wider variety of soils and pavement types would be needed.

OBJECTIVE/SCOPE

- To coordinate provincial highway programs for long-term pavement performance measurements and observations so as to maximize the effectiveness of the results from these programs and from the SHRP study.
- To provide a focus for discussion among provinces and territories of analyses of results, and to foster uniformity in design principles.

TARGETED PRODUCTS

Data on Canadian pavements to be shared across the country and with the United States.

Better performance prediction models; more cost-effective design and rehabilitation strategies.

RATIONALE FOR INCLUSION IN C-SHRP

Gap resulting from selection criteria for SHRP sections.

LINKAGES

Commonality of need among provinces.

Complementary to the C-SHRP Integral Program.

B-1

PRELIMINARY PROJECT DESIGN

- For an undertaking of this magnitude, a task force of provincial pavement specialists should be set up.
- Once the most economical set of 'non-SHRP' sections have been selected from all provinces, the monitoring and analysis will be analogous to that for 'SHRP' sections.
- From time to time, a consultant will be hired to provide state-of-the-art updates, to identify opportunities for implementation and to develop materials for such implementation.

TIMING REQUIREMENTS

Five years.

COST ESTIMATES

Depending on equipment needs for monitoring.

Five years at $100,000 = $500,000.

PROJECT # B-2

See also Project Statement 86-12 submitted to RTAC for 1986/87 fiscal year

C-SHRP TECHNICAL RESEARCH AREA

Long-term Pavement Performance

PROJECT TITLE

Design Method for Bituminous Surface Treatments

PROBLEM STATEMENT/BACKGROUND

Bituminous Surface Treatment (BSTs) are being used more and more as a surfacing structure on many of Canada's low-volume roads. They serve as an improvement upon gravel surfaces but do not have the high capital costs of hot-mix asphalt pavements. There is no design procedure for matching materials and their application to traffic type and volume and environment.

OBJECTIVE/SCOPE

1. To evaluate the performance of BST under controlled conditions.
2. To establish guidelines for the use of single and double BSTs.
3. To establish a procedure for determining granular depths for BSTs.
4. To establish a design procedure to match the granular material, the binder, and traffic and environmental conditions.

TARGETED PRODUCTS

Design guidelines based on appropriate structural considerations for the anticipated traffic volumes.

RATIONALE FOR INCLUSION IN C-SHRP

Seventy percent of all roads in Canada are low-volume roads. BST is a good low-cost strategy for construction of such roads. The SHRP LTPP Program concentrates on medium to high-volume roads. Inclusion of this project in C-SHRP will provide information on the full spectrum of construction techniques.

LINKAGES

Commonality of need among provinces.

PRELIMINARY PROJECT DESIGN

Test sections will be selected in five geographic areas. Each section will have two subgrade types and four depths of gravel base per subgrade type. Each section will have six subsections, each ½ km long, four with single BSTs and two with double BST. Separate sections of BST would be identified for different application rates and types of aggregate and binders. Moisture, traffic type and volume, and costs will be monitored for a minimum of five years.

TIMING REQUIREMENTS

5 years, but may have to compress into 4 years.

COST ESTIMATES

Year 1	$150,000
Year 2	200,000
Year 3, 4, 5, 6	250,000
Total	$600,000

PROJECT # B-3

C-SHRP TECHNICAL RESEARCH AREA

Long-term Pavement Performance

PROJECT TITLE

The Effects of Very Heavy Loads on BST Surfaces

PROBLEM STATEMENT/BACKGROUND

In some jurisidictions because of low traffic volumes, asphalt cement pavements are not warranted until some time in the future. Instead, BST sections are build. From time to time surfaces of roads with BST are subjected to very heavy (truck) loads.

Long term planning with BST as a construction alternative requires a number of questions to be answered on the suitability and performance of BST under heavy truck loading:

- -- life expectancy;
- -- maintenance costs and methods;
- -- probable causes of failure;
- -- cost-benefit comparisons with conventional asphalt cement pavements.

OBJECTIVE/SCOPE

- To answer the above questions on suitability and performance of BST under heavy truck loading.
- To evaluate current BST construction practice in relation to established BST design procedures.
- To develop and implement an evaluation and condition rating procedure for BST.
- To evaluate the effect on BST performance of alternative base course designs.

TARGETED PRODUCTS

See OBJECTIVE/SCOPE above.

RATIONALE FOR INCLUSION IN C-SHRP

Of benefit to jurisdictions with low traffic volumes combined with a large percentage of trucks.

B-3

LINKAGES

If funding is available for both Project B-2, Design Method for Bituminous Surface Treatments, and Project B-3, The Effects of Very Heavy Loads on BST Surfaces, coordination between these two projects would likely yield economies of scale.

PRELIMINARY PROJECT DESIGN

A number of test sections and a number of supplementary observation points will be set up to incorporate a range of BST/basecourse combinations as well as conventional A.C.P. designs. The test sections would allow investigation of BST performance in relationship to asphalt and aggregate properties and application rates; winter maintenance procedures; varying granular base course depths and subgrade conditions.

Each location will be periodically evaluated with respect to structural capacity and distress. Drilling and sampling will be carried out to determine accurately base course and subgrade characteristics. Traffic characteristics will be recorded by counts and weigh scale measurements.

TIMING REQUIREMENTS

Four years.

COST ESTIMATES

$250,000

Projects Addressing Maintenance Cost-effectiveness

PROJECT # C-1

C-SHRP TECHNICAL RESEARCH AREA

Maintenance Cost-effectiveness

PROJECT TITLE

Removal of Hazards due to Ravelling of Granular Shoulder Material at Edge of Pavement

PROBLEM STATEMENT/BACKGROUND

'Ravelling' of granular shoulder material occurs at the edge of pavements. In severe cases of ravelling, material moves away from the pavement edge, leaving a vertical drop that is very hazardous to the driver who might inadvertently wander close to the edge of the pavement.

OBJECTIVE/SCOPE

A solution is sought in terms of the materials, equipment and improved methods which would remove this hazard.

The relative cost-effectiveness of gravel versus paved shoulders should be explored.

TARGETED PRODUCTS

Improved materials and equipment specifications.

Improved construction and maintenance methods.

Relative cost-effectiveness of gravel versus paved shoulders.

RATIONALE FOR INCLUSION IN C-SHRP

Identified by experts in maintenance at the Winnipeg workshop.

Gravel shoulders occur in many jurisdictions across Canada and are susceptible to this hazard. A cost-effective solution to this problem would result in enhanced safety.

LINKAGES

Commonality of need among provinces.

Some components of the approach will be analogous to those in SHRP Project #3, Improved Materials and Equipment for Pavement Surface Repairs and Crack Filling.

C-1

PRELIMINARY PROJECT DESIGN

1. Monitor some locations in which this is likely to occur.

2. Develop tentative remedial methods. Implement at the beginning of summer and monitor performance.

3. Explore cost-effectiveness of gravel versus paved shoulders.

TIMING REQUIREMENTS

Three years.

COST ESTIMATES

$130,000

PROJECT # C-2

C-SHRP TECHNICAL RESEARCH AREA

Maintenance Cost-effectiveness

PROJECT TITLE

Demonstration of Technology to Automate the Measurement of Pavement Distress

PROBLEM STATEMENT/BACKGROUND

Procedures for measuring pavement distress vary across Canada, from manual to automated methods. Manual methods are inconvenient, time-consuming and expose technicians to danger from traffic.

Prototype technology, e.g. the Automatic Road Analyser (ARAN) Vehicle, exists and a demonstration of its convenience and accuracy, around the country, is needed.

OBJECTIVE/SCOPE

A demonstration circuit involving interested jurisdictions is arranged to acquaint them with technology.

TARGETED PRODUCTS

Evaluation of appropriateness of equipment for use by individual jurisdictions.

RATIONALE FOR INCLUSION IN C-SHRP

Measurement of ruts was identified by experts at the Winnipeg workshop.

This project will present Canadian jurisdictions with the opportunity to replace current inconvenient, time-consuming and hazardous procedures. It will also help to preserve and exploit Canada's technical edge in this area.

LINKAGES

Commonality of need among provinces and territories.

PRELIMINARY PROJECT DESIGN

Interested jurisdictions lay out pavement sections for demonstration of technology, and with help of researcher reporting to RTAC, report on feasibility of incorporating equipment into their distress-logging procedures.

C-2

TIMING REQUIREMENTS

One year.

COST ESTIMATES

$100,000

PROJECT # C-3

C-SHRP TECHNICAL RESEARCH AREA

Maintenance Cost-effectiveness

PROJECT TITLE

Corrective Measures for Ruts in Flexible Pavements

PROBLEM STATEMENT/BACKGROUND

Ruts occur in the wheel tracks in flexible pavements. Methods of restoration of the pavement cross-section vary, and yield varying levels of success. Coldplaning, heater planing, granular lift and surface treatment and hot-mix patching are all methods whose effectiveness has not been documented and which, therefore, cannot be incorporated into a comprehensive system for improving cost-effectiveness.

OBJECTIVE/SCOPE

Documentation of the effectiveness of different methods of restoration.

TARGETED PRODUCTS

Guidelines for corrective measures under varying conditions.

RATIONALE FOR INCLUSION IN C-SHRP

Identified by experts in maintenance at the Winnipeg workshop.

LINKAGES

Commonality of need among provinces.

Some components of the approach will be analogous to those in SHRP Project #3, Improved Materials and Equipment for Pavement Surface Repairs and Crack Filling.

PRELIMINARY PROJECT DESIGN

1. Monitor some locations in which rutting has occurred.
2. Develop tentative remedial methods. Implement at the beginning of the program and monitor year after year.

C-3

TIMING REQUIREMENTS

Full performance data has to be compiled over several years.

COST ESTIMATES

$50,000

PROJECT # C-4

C-SHRP TECHNICAL RESEARCH AREA

Maintenance Cost-effectiveness.

PROJECT TITLE

Improved Materials and Equipment for Pavement Surface Repairs & Crack Filling.

PROBLEM STATEMENT/BACKGROUND

Increases in maintenance productivity and improvements in resource allocation must be made if our maintenance forces are to protect our highway infrastructure investment and provide a level of service acceptable to road users under existing and expected budget pressures.

OBJECTIVE/SCOPE

The research would evaluate materials, equipment and methods used in patching and sealing pavement joints and cracks in flexible pavements under in a range of traffic volumes in Canadian environment, soil and other conditions.

TARGETED PRODUCTS

Equipment and material specifications and procedural guides for pavement maintenance in Canadian conditions.

RATIONALE FOR INCLUSION IN C-SHRP

Complementary Canadian experience to add to and draw from related SHRP projects. While we can monitor SHRP research in this area, higher budgets and more severe climatic conditions in Canada make a complementary study necessary.

LINKAGES

Commonality of need.

PRELIMINARY PROJECT DESIGN

1. Develop a data base that permits increased understanding of the effectiveness of currently used materials and equipment for pavement surface repair and crack filling in Canada.

2. Identify potential alternative materials, equipment and methods.

3. Evaluate and report on the potential productivity and resource allocation improvement of each alternative.

4. Field test promising candidates.

5. Report findings and make recommendations.

COST ESTIMATE

$300,000 over 5 years.

Projects Addressing Protection of Concrete Bridge Components

PROJECT # D-1

C-SHRP TECHNICAL RESEARCH AREA

Protection of Concrete Bridge Components

PROJECT TITLE

To Quantify the Service Life of Existing Canadian Methods of Protection and Rehabilitation on Decks, Beams, Piers and Abutments

PROBLEM STATEMENT/BACKGROUND

There exists at present no mechanism for documenting and sharing good local solutions to the problems of concrete bridge component deterioration. A simple compendium of what measures are currently being taken, for which component, by what criteria (rules of thumb), under what conditions, and with what results, would be a good start towards systematizing our national experience.

OBJECTIVE/SCOPE

A concrete specialist visits a selection of jurisdictions across the country (those with records) and, taking some pains to keep the data clean, compiles some cross-tabulations of the above variables.

TARGETED PRODUCTS

In the first instance, those factors which are correlated with long service lives; then predictive equations based on the compiled data.

RATIONALE FOR INCLUSION IN C-SHRP

Identified by experts at the Winnipeg workshop.

LINKAGES

Shares good regional solutions with others in Canada.

To be shared in turn with SHRP.

PRELIMINARY PROJECT DESIGN

See OBJECTIVE/SCOPE.

D-1

TIMING REQUIREMENTS

Three years.

COST ESTIMATES

$300,000

PROJECT # D-2

C-SHRP TECHNICAL RESEARCH AREA

Protection of Concrete Bridge Components

PROJECT TITLE

Economic Feasibility of Making Corrosion-Resistant Reinforcing Steel

PROBLEM STATEMENT/BACKGROUND

Currently, epoxy coating is applied to steel reinforcing bars to make them corrosion resistant. The cost of the bars in place doubles when this treatment is applied. This project will answer the question of whether the material in the steel bar can be modified to achieve corrosion resistance at a price less than that of expoxy-coated bars.

OBJECTIVE/SCOPE

Theoretical and laboratory work will provide the base data for the economic analysis.

TARGETED PRODUCTS

An economic analysis leading to a 'ball-park' estimate of whether modification of the steel in reinforcing bars can compete economically with the current technology of applying epoxy coating.

RATIONALE FOR INCLUSION IN C-SHRP

If the method of modifying the steel is a more economic alternative than epoxy-coated bars, then the pay-back can be considerable.

LINKAGES

Common benefit to all jurisdictions.

PRELIMINARY PROJECT DESIGN

Some theoretical and laboratory work will be necessary to identify economic methods of modifying the steel. This will provide the base data for the economic analysis.

D-2

TIMING REQUIREMENTS

Two years.

COST ESTIMATES

$60,000

PROJECT # D-3

C-SHRP TECHNICAL RESEARCH AREA

BRIDGE ISSUES

(i.e. other than that of the protection of existing concrete bridges against corrosion, on which SHRP concentrates)

PROJECT TITLE

Synthesis of Research on Load-carrying Capacity of Bridges into Evaluation Guidelines

PROBLEM STATEMENT/BACKGROUND

Not all experts agree on how to settle the question of how much load a particular bridge can carry -- a question which has little to do with design capacity. For example, bridges in New York and Ontario have been built to the same design standards, but New York has set its maximum vehicle load at about 36 tons whereas Ontario has set its maximum at about 72 tons.

Research reports are emerging from a number of efforts, e.g. that by NCHRP in the United States. It is important that, at some time in the future, these reports be synthesized to produce bridge evaluation guidelines which would take account of actual vehicle populations in the various jurisdictions. Uncertainty about load capacity will lead to premature, expensive rehabilitation and reconstruction of bridges.

OBJECTIVE/SCOPE

A wait of about two to three years is recommended, after which a bridge specialist develops a synthesis.

TARGETED PRODUCTS

A manual of unified theories/evaluation guidelines for different kinds of bridges.

RATIONALE FOR INCLUSION IN C-SHRP

Makes available to provinces, territories and municipalities in Canada, the latest findings from research -- as an aid to bridge evaluation and to the rationalization of loading legislation.

LINKAGES

A gap in the SHRP plan, the filling of which will lead to substantial pay-off.

PRELIMINARY PROJECT DESIGN

A task force and specialist should be set up to keep abreast of developments in this area for two years. The specialist should then develop a unified set of theories/evaluation guidelines during the next two years.

TIMING REQUIREMENTS

4 years.

COST ESTIMATES

$120,000

Projects Addressing Innovations in Cement and Concrete Technology

PROJECT # E-1

C-SHRP TECHNICAL RESEARCH AREA

Cement and Concrete Technology

PROJECT TITLE

Investigation and Documentation of the Benefits of Fibre Shotcrete and Development of Standard Procedures for its Application

PROBLEM STATEMENT/BACKGROUND

Recently, some jurisdictions, e.g. Alberta, have reported favourably on fibre shotcrete. It remains to investigate and document, for the benefit of other jurisdictions, the procedures for making and using this material and the level of benefits, such as toughness and impact resistance, to be derived from its use; for example, in bridge substructures.

OBJECTIVE/SCOPE

In this project the theoretical benefits to be derived from this material under different service conditions will be explored. Successful applications, e.g. in Alberta, will be documented and a small number of field trials carried out. A manual of standard procedures for various applications of this material will be developed.

TARGETED PRODUCTS

See OBJECTIVE/SCOPE above.

RATIONALE FOR INCLUSION IN C-SHRP

Identified by experts in cement and concrete technology at the Winnipeg workshop. This project would document the use of fibre shotcrete in substructure rehabilitation and stabilization of rock cuts for use by Canadian jurisdictions.

LINKAGES

Technology sharing.

Brings all provinces and territories up to date on this material.

PRELIMINARY PROJECT DESIGN

Expert reports to the RTAC task force in cement and concrete technology.

Some theoretical and laboratory work will precede the field investigations. The expert will acquaint himself with successful applications, e.g. in Alberta, and report on them. He will direct a small number of field trials and analyze early results. Finally, he will develop a manual of standard procedures for various applications of this material.

TIMING REQUIREMENTS

Three years.

COST ESTIMATES

$150,000

PROJECT # E-2

C-SHRP TECHNICAL RESEARCH AREA

Cement and Concrete Technology

PROJECT TITLE

Investigation of the Mechanisms of, and Development of Methods of Defense against, Alkali-Carbonate and Other Reactivity Problems

PROBLEM STATEMENT/BACKGROUND

The nature of the reactions involved in 'alkali-carbonate reactivity' -- between some dolomitic limestone aggregates and the alkalis in cement -- is still imperfectly understood. Fortunately, reactive carbonate rocks are not widespread, but the problem does occur in some regions of Canada, e.g. Ontario and Quebec. Other reactivity problems, e.g. "D" cracking in Manitoba, remain to be fully understood.

There is need for an investigation of the mechanism of these reactions, for development of screening methods for concrete constituent materials, and for mitigating measures that might be applied to structures that have been built with reactive aggregates.

OBJECTIVE/SCOPE

The basis of the project will be a review of the state-of-the-art and development of further theoretical understanding of the mechanism of these reactions. Based on this understanding, methods of screening potentially reactive materials before construction will be developed. For existing structures in which the problem already exists, methods to mitigate its effect will be developed.

TARGETED PRODUCTS

Report that enhances the current state of knowledge.

Manual of standard procedures for screening out potentially harmful concrete constituent materials.

Manual of standard procedures for mitigating the effects of alkali-carbonate and other reactivity problems in existing structures.

RATIONALE FOR INCLUSION IN C-SHRP

Identified by experts in cement and concrete technology at the Winnipeg workshop.

This project presents the opportunity to advance the state-of-the-art in concrete technology and to the construction of bridges and pavements.

LINKAGES

This project will bring regions of Canada with potential reactivity problems up to the state-of-the-art.

PRELIMINARY PROJECT DESIGN

The project will consist mainly of theoretical and laboratory work. Once the mechanisms of alkali-carbonate and other reactivity problems have been investigated, the screening tests for concrete materials and the methods for mitigating existing problems will be developed.

TIMING REQUIREMENTS

Three years.

COST ESTIMATES

$300,000

PROJECT # E-3

C-SHRP TECHNICAL RESEARCH AREA

Cement and Concrete Technology

PROJECT TITLE

Development of Premium Cement

PROBLEM STATEMENT/BACKGROUND

Cements which meet standard specifications, nevertheless show a wide range of durability when used in structures that have to meet the very exacting environmental conditions which exist in Canada. There is need to develop a cement which in combination with common aggregates will produce premium performance in concrete structures.

OBJECTIVE/SCOPE

Theoretical and laboratory work will precede the production of any pilot batches in a manufacturer's plant

TARGETED PRODUCTS

The recipe for one 'near perfect' cement or for several 'very good' ones with indications of the trade-off between price and performance.

RATIONALE FOR INCLUSION IN C-SHRP

Will attempt to build insurance, systematically, against the several deterioration mechanisms to which concrete falls victim. SHRP narrowly concentrates on corrosion.

LINKAGES

Common benefit to all jurisdictions.

PRELIMINARY PROJECT DESIGN

The researcher will attempt to eliminate from his laboratory cements the potential for each of the modes of concrete deterioration, one at a time. If there is interaction between such measures which preclude the elimination of all such negative factors simultaneously, then a small number of 'very good' ones will be developed for pilot manufacturing runs.

E-3

TIMING REQUIREMENTS

Three years.

COST ESTIMATES

$500,000

Projects Addressing Innovation in Snow and Ice Control

PROJECT # F-1

Reference: Proposal for Solving Highway Snowdrifting Problems submitted to Supply and Services Canada, Unsolicited Proposals Program by Morrison Hershfield Limited, Guelph, Ontario

PROJECT TITLE

(Buying into) Project to solve Highway Snowdrifting Problems

PROBLEM STATEMENT/BACKGROUND

Reduction of the amount of snow reaching a roadway is one of the fundamental approaches to cutting costs of clearance. Considerable resources are used to remove accumulations that continue for days after the original snowstorm is over. Blowing snow is the problem under certain road elevations and alignments.

OBJECTIVE/SCOPE

Guidelines, in the form of a computer program and manuals, are sought for existing roads where snowdrifting/blowing is a problem (retro-fitting), and as input into the design of new roads.

TARGETED PRODUCTS

Computer program and manuals should synthesize the state of the art and indicate their own limits in the case of problem situations which resist solution.

RATIONALE FOR INCLUSION IN C-SHRP

Identified by experts in snow and ice control at the Winnipeg workshop.

Morrison Hershfield's proposal has already been well received by some provinces.

LINKAGES

Commonality of need among provinces

Sharing results with SHRP

PRELIMINARY PROJECT DESIGN

Canada will be divided into six climatic zones and problem sites selected from each. Remedial installations will be observed before results are systematized into a snow control manual/computer aided design system (CAD).

F-1

TIMING REQUIREMENTS

One year.

COST ESTIMATES

(Buy in for) -- $80,000

PROJECT # F-2

Reference: Proposal for Solving Highway Snowdrifting Problems submitted to Supply and Services Canada, Unsolicited Proposals Program by Morrison Hershfield Limited, Guelph, Ontario

See also Project F-1 in this report

PROJECT TITLE

Expert System to Combine Snowdrifting Control Expertise with Geometric Design Constraints

PROBLEM STATEMENT/BACKGROUND

The reference proposal and Project F-1 in this report address the development of a computer program and manuals to solve snowdrifting problems. It is not fully optimal for design technicians to apply this program first and then check whether the solution meets geometric design constraints.

OBJECTIVE/SCOPE

A merging is sought between guidelines for the installation of remedial measures and geometric design constraints.

TARGETED PRODUCTS

A user-friendly expert system built with one of several commercially available 'shells' now available on the market.

RATIONALE FOR INCLUSION IN C-SHRP

This area was identified by experts in snow and ice control at the Winnipeg workshop.

Morrison Hershfield's proposal for the parent project (Project F-1 in this report) has already been well received by some provinces.

This is a case where a little extra effort would increase the yield from the parent project.

LINKAGES

Commonality of need among provinces.

Sharing results with SHRP.

PRELIMINARY PROJECT DESIGN

A search will be conducted of available highway design software. Expert system shells will be assessed, and one, preferably personal computer based, will be selected.

During Project F-1, the structure of the snowdrifting program will become better defined and merging the two sets of considerations will begin.

TIMING REQUIREMENTS

More or less parallel to Project F-1: three years.

COST ESTIMATES

$20,000 a year for three years = $60,000

PROJECT # F-3

See also Project Statement 86-23 submitted to RTAC for 1986/87 fiscal year

PROJECT TITLE

Immobilizing Deicing Chemicals on Roadway Surfaces -- Phase I

PROBLEM STATEMENT/BACKGROUND

In recent years road authorities have used bituminous surface courses with an open texture, which reduces tire/pavement noise and which allows immediate drainage of water, thereby increasing wet pavement resistance. One problem with these pavements, however, is that deicing chemicals are not retained: once dissolved, they drain away. The answer so far has been to increase the application rate.

OBJECTIVE/SCOPE

A solution is sought either through modifications in the design of the surface course or through improved maintenance procedures, to retain the deicing chemicals on the surface until they are fully 'spent'.

TARGETED PRODUCTS

Improved mix design and/or maintenance guidelines.

RATIONALE FOR INCLUSION IN C-SHRP

Referred by CHTRD. This project offers the potential to save on the cost of deicing chemicals and to reduce environmental damage.

LINKAGES

Commonality of need among provinces.

PRELIMINARY PROJECT DESIGN

Only laboratory work is envisaged in this first phase.

The method might be either applications of a treatment at the onset of winter or a separate or integral application at the time of salting. The treatment must not affect the pavement material or its drainage properties in the absence of snow and ice. It must be environmentally safe and preserve skid resistance.

F-3

TIMING REQUIREMENTS

Twelve months.

COST ESTIMATES

$30,000